LIVERPOOL GEOLOGICAL ASSOCIATION.

TRANSACTIONS.

VOLUME III.

SESSION 1882-83.

Price Five Shillings.

LIVERPOOL:
PUBLISHED BY HENRY YOUNG, 12, SOUTH CASTLE STREET.

1883.

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The Authors are alone responsible for the facts and opinons expressed in their Papers.

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FIELD MEETINGS AND EXCURSIONS—

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LIVERPOOL

GEOLOGICAL ASSOCIATION.

ANNUAL REPORT,

1882.

LIVERPOOL GEOLOGICAL ASSOCIATION,

FREE LIBRARY, WILLIAM BROWN STREET, LIVERPOOL.

Council.

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HENRY BRAMALL, M. INST. C.E.

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Botanic View, Smithdown Lane, Liverpool.

SECRETARY,

OSMUND W. JEFFS,

8, Queen's Road, Rock Ferry.

THIS COUNCIL WILL CONTINUE UNTIL OCTOBER, 1883.

LIVERPOOL GEOLOGICAL ASSOCIATION.

ANNUAL REPORT,

Session 1881-82.

2nd October, 1882.

Your Council have pleasure in reporting that, since the last Annual Meeting, 47 new members have joined the Association. There have been 5 resignations. They regret also to announce the loss by death of one member, Mr. Baruchson. The Members now on the roll number 94.

During the past session there have been held eleven Evening Meetings, and the following Papers have been read and discussed:—

Notes on the Garston Drift Deposits, by Isaac E. George

The Formation and Changes of Minerals, by George Tate, Ph. D., F.G.S.

Fossil Footprints, by Thomas Shilston, M.I.N.A.

Chemical Action in relation to Geological Change, by A. Norman Tate, F.I.C.

Rivers, by T. Mellard Reade. C.E., F.G.S., F.R.I.B.A.

Iron Pyrites, by H. T. Mannington.

Notes on Ferruginous Bands in the Sandstones of this District, by A. Norman Tate, F.I.C.

Volcanoes, by Daniel Clague.

Fossil Horses, by Anthony W. Auden.

Salt, by J. Meredydd Roberts.

Some Geological Notes on a Cornish Beach, by William Semmons.

Theories of Volcanic Energy, by Thomas Brennan.

Diamonds, by Charles E. Miles.

Field Meetings have been held as follows:—

1881.		
1st October	...	Owens College Museum, Manchester.
5th November	...	Exeavations at Linacre.
1882.		
11th March	...	Hoylake and West Kirby.
10th April	...	Buxton.
29th May	...	Witton Hall Rock Salt Mine, Northwich
17th June	...	Wallasey, Flaybrick Hill & Bidston.
8th July	...	Dawpool.
7th August	...	Beeston and Peckforton Hills.
26th August	...	Burton Point.
18th Sept.	...	Sankey Brook Colliery, St. Helens, *(Joint Excursion with the Liverpool Science Students' Association.)*
28th Sept.	...	Museum of the Chester Society of Natural Science, Chester.

At the Soirée of the Associated Societies of Livepool, held in St. George's Hall, on 21st December, 1881, this Association contributed a collection of minerals and Geological specimens; and, at the request of the Burnley Literary and Scientific Club, a similar collection was exhibited at their Soirée, on the 2nd February, 1882.

The following Donations and Exchanges have been received during the Session:—

"Abstracts of the Proceedings" of the Geological Society of London, Sessions 1881-1882;—*presented by Mr. G. H. Morton, F.G.S.*

"Transactions" of the Edinburgh Geological Society, Sessions 1880-1;—*from the Society.*

"Transactions" of the Manchester Geological Society, Vol. XVI, Sessions 1880-1, 1881-2;—*from the Society.*

"Proceedings" of the Chester Society of Natural Science, Nos. I (1874), and II (1878);—*from the Society.*

"Proceedings" of the Belfast Naturalists' Field Club, 1880-81 (Vol. II, Part I,)—*from the Club.*

"Proceedings" of the Liverpool Philomathic Society, Vol. XXVII, Session 1881-82;—*from the Society.*

Index to first 25 vols. of Transactions of the North of England Institute o Mining and Mechanical Engineers,—*from the Institute.*

"Geological Papers" (1874 to 1881), by T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.,— "The Chalk Masses in the Contorted Drift of Cromer," by the same;—"The relations of the Glacial Deposits of the Clyde and Forth to those of the North-West of England and North of Ireland," by the same;—*presented by the Author.*

"Volcanoes: what they are and what they teach," J. W. Judd;—*presented by Mr. Henry Bramall, M. Inst., C.E., (President).*

"Chemical and Geological Essays," Sterry Hunt;—*presented by Mr. A. Norman Tate, F.I.C.*

"Varieties of the shells belonging to the genus *Nassa*, On the," by Fredk. P. Marrat;—*presented by the Author.*

"Geological Manual," De La Beche;—*presented by Mr. George Lewis.*

"Geological Excursions round the Isle of Wight," Dr. Mantell;—*presented by Mr. Herbert Fox.*

"Geology of the Counties of England and Wales," W. J. Harrison "Geological Rambles round London,"—"Fifty Years of Science," Sir John Lubbock.—*presented by Mr. O. W. Jeffs, (Secretary).*

"Lardner's Museum of Science," Vols. V and VI;—*presented by Mr. Daniel Clague.*

"Tabular View of Characteristic British Fossils, A," (Chart);—*presented by Mr. Hopkin Thomas.*

A series of Diagrams and colored Sections, principally illustrating the Geology of the Country round Liverpool;—*presented by Mr. Willem S. Logeman, Lit. Hum. Cand. M.R.C.P.*

Papers: "The Philosophy of Recreation," by J. C. Brumwell, M.D.; and "Geoffrey Chaucer," by Henry Houlding;—*presented by the Burnley Literary and Scientific Club.*

Reports (Annual) of the Chester Society of Natural Science (Nos. 9, 10, and 11, 1879-82);—Entomological Society of Lancashire and Cheshire (1881);—Liverpool Science Students' Association (1881-2);—

Liverpool Free Library and Museum (1881);—Chester Free Library (Nos. 1, 2, and 3,- -1878-80);—Birkenhead Free Library (1880-1);—Atkinson Free Library, Southport (1881-2);—*from the various Societies and Committees of the Libraries enumerated.*

The printing of the Transactions has been continued, and is now up to date.

The Treasurer's Financial Statement, having been duly audited in accordance with the rules, is appended to this Report. After providing for all liabilities there is a balance of Cash in hand of £1 11 6.

The officers of the Association for the ensuing Session will require to be elected at this Meeting, in accordance with Rule III.

The regulations for the printing of the Transactions will remain the same as mentioned in the Report for 1881 (page 4), except that, in consequence of the increased number of copies required, the rate per page, payable by the Author, will have to be increased from 2/- to 2/6 for all beyond the first four.

The Council feel that the results of the past Session are very encouraging, alike as regards the Papers read, the large attendances at the various Evening and Field Meetings, and the great interest manifested in the proceedings of the Association. They would wish to impress upon the Members the necessity for continued efforts on the part of each one to ensure success in the future, by the production of Papers introducing interesting subjects for discussion.

The advantages of a good reference Library of Geological Books, Maps, Sections, and M.S.S., also works relating to other branches of Physical Science, are so obvious that the Council feel that they have only to bring the desirability of establishing such a Library to the notice of members to obtain their hearty co-operation. So soon as a sufficient number has been collected, a Catalogue of the Books will be printed, and arrangements will be made for their circulation.

LIVERPOOL GEOLOGICAL ASSOCIATION, *In Account with the Treasurer.*

FOR THE YEAR ENDING SEPTEMBER, 1882.

DISBURSEMENTS.

Date		£	s.	d.
1882 Sept.	To Attendant at Meetings	1	7	6
,,	,, Printing and Stationery	23	0	8
,,	,, Postages and Incidentals	7	9	5
,,	,, Balance	1	11	6
		£33	9	1

RECEIPTS.

Date		£	s.	d.	£	s.	d.
1881. Sept. 30,	By Balance brought forward				3	13	4
1882. Sept.	,, Subscriptions :— viz. :—						
	1 for the year 1880-81	0	5	0			
	94 ,, ,, 1881-82	23	10	0			
	2 ,, ,, 1882-83	0	10	0	24	5	0
,,	,, Receipts from members for Printing				5	8	3
,,	,, Bank Interest				0	2	6
					£33	9	1

Date		£	s.	d.
1882. Sept.	By Balance brought down	1	11	6

Audited and found correct,

ANTHONY W. AUDEN.
HOPKIN THOMAS.

Liverpool, 6th September 1882.

W. H. WALKER,
TREASURER.

LAWS

OF THE

LIVERPOOL GEOLOGICAL ASSOCIATION,

Established 3rd June, 1880.

RULES PASSED 15TH NOVEMBER, 1880.

OBJECT.

The object of the LIVERPOOL GEOLOGICAL ASSOCIATION *is to promote the study of Geology and its allied Sciences.*

RULES.

I.

That every Candidate for membership shall be proposed and seconded by two members of the Association, and ballotted for at the next Ordinary meeting; and the consent of three-fourths of the members then present shall be necessary for the admission of such Candidate.

The proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the members any remarks the Council may deem it expedient to make thereon.

II.

Every member shall pay an annual subscription of Five Shillings, payable on the 1st October, or in the case of a new member, within one month after election. Any member not paying the subscription within three Calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association.

III.

The Officers of the Association shall be a President, Vice-President, Treasurer, Secretary, and five other members, who together shall constitute the Council to manage and direct the affairs of the Association. Five to form a quorum. The officers shall be elected at the Annual Meeting, to be held in October; retiring officers shall be eligible for re-election. Any vacancy occurring during the year shall be filled up by the Council.

IV.

The Treasurer's Financial Statement shall be presented to the Association, with the Annual Report, after having been duly audited by two members proposed, seconded, and elected at the last meeting of the Session.

V.

The Ordinary Meetings shall be held on the first Monday in each month, at Eight o'clock in the evening. The order of proceeding at such meetings shall be:—

1.—The ordinary business of the Association.
2.—Miscellaneous Communications.
3.—Original Papers or Communications, to be followed by discussion thereon.
4.—Announcement of business for the next meeting.

VI.

A Special Meeting may be called at any time by the Council; and they shall be bound to call such a meeting on receipt of a requisition signed by not less than ten members, stating the purpose for which the meeting is to be convened. Seven days' notice of a Special Meeting shall be given to every member, such notice to specify the business to be considered, and the meeting shall be held within twenty-one days after the receipt of the requisition. No other business shall be considered at a Special Meeting except that for which it has been called.

VII.

Field Meetings shall be held at places of Geological interest but none of the private business of the Association shall be transacted on such occasions.

VIII.

The votes on any question brought before the Association shall be taken by a show of hands, except those for the election of officers and new members, which shall be taken by ballot.

IX.

The Manuscript of every Paper read, or a clear and legible copy thereof, written on Foolscap, shall become the property of the Association, and shall be placed in the Library for the use of the members.

X.

In case of non-compliance with the Rules of the Association, or misconduct by any member, such member may be requested by the Council to resign. Failing to do so, the Council may bring the case before a meeting of the Association which shall deal with it as may seem expedient.

XI.

Every member may introduce a friend at any Ordinary or Field Meeting of the Association, provided, however, that no person qualified to become a member be admitted as a Visitor more than twice in the same year.

XII.

No addition to or change in these Rules shall be made, except by a majority of not less than two-thirds of the members present at a Special Meeting to be convened for that purpose.

LIVERPOOL GEOLOGICAL ASSOCIATION.

FORM A.

M ....

....

being desirous of admission to the Association, We, the undersigned, recommend h as a proper person to become a Member.

Dated.................................18

Proposed by..

Seconded by ....

Date Proposed..18

Date Elected 18

Signature of Candidate..

.....................................Secretary.

REGULATIONS FOR THE ADMISSION OF MEMBERS.

RULE 1.—That every Candidate for membership shall be proposed and seconded by two members of the Association, and balloted for at the next ordinary meeting; and the consent of three-fourths of the members then present shall be necessary for the Admission of such Candidate.

The proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the members any remarks the Council may deem it expedient to make thereon.

RULE 2.—Every Member shall pay an Annual Subscription of Five Shillings, payable on the 1st October, or, in the case of a new member, within one month after election Any member not paying the subscription within three calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association.

LIVERPOOL GEOLOGICAL ASSOCIATION.

LIST OF MEMBERS.

Auden, Anthony W., ...	**94, Jacob Street, Liverpool**
Bramall, Henry, M. Inst., C.E., ..	**8, Balmoral Road, Elm Park, L'pool**
Brasb, Miss L. A., ...	**8a, Grove Street, Liverpool**
Brennan, Thomas, ...	**87, Towson Street, Liverpool**
Broadfoot, Bryce M., ...	**67, Huskisson Street, Liverpool**
Broadhurst, Miss E..	**Belmont Drive, Newsham Park, Liverpool**
Broadhurst, Miss M. A., ..	**6, Rokeby Terrace, Hillhead, Glasgow**
Brodie, Alexander, ...	**56, Hatherly Street, Liverpool**
Browne, A. H., ...	**33, Hampden Street, Higher Tranmere, Cheshire**
Cade, Lawrence W.	**15, Upper Parliament Street, L'pool**
Capon, R. M., L.D.S., ...	**114, Vine Street, Liverpool**
Carter, C. W., ...	**4, Springfield, Everton, Liverpool**
Clague, Daniel, ...	**81, Lime Grove, Lodge Lane, L'pool**
Connell, T. R., ...	**Melville Chambers, Lord Street, Liverpool**
Davies, David, ...	**Elsham House, Round Oak, Brierley Hill, Staffordshire**
Deuchar, P. B., ...	**17, Kingsley Road, Liverpool**
Duff, Samuel,..	**55, St. Martin's Cottage, Ashfield Street, Liverpool**
Dunsford, A. J., ...	**Wynch House, Seacombe, Cheshire**
Edwards, George H., ...	**2, Whitechapel, Liverpool**
Elias, O. H., ...	**6, The Elms, Toxteth Park, L'pool**
Evans, J. C., ...	**87, Ranelagh Street, Liverpool**
Finlay, R F..,..	**Slater Court, Castle Street, L'pool**
Fowler, Thomas Richard, ..	**139, Crown Street, Liverpool**

Fox, Herbert, ...	11, Ash Grove, Seaforth
George, Isaac E., ...	95, Cawdor Street, Liverpool
Green, Charles H., ...	9, Lydia Ann Street, Liverpool
Grisewood, W., ...	Liscard Park, Liscard, Cheshire
Gould, Joseph, ...	28, Bedford Place, Seaforth
Hall, Hugh F., F.G.S., ...	Greenheys, Grove Road, Wallasey, Cheshire
Hedley, J. L., H.M. Inspector of Mines,	The Gables, Flooker's Brook, Chester
Henson, Samuel	227, Strand, London
Hills, William, ...	Fountain Street, Higher Tranmere, Cheshire
Houlding, William	34, Tynemouth Street, Liverpool
Howard, J. D., ...	109, Christian Street, Liverpool
Hunt, T. S., ...	9, Wordsworth Street, Liverpool
Jeffs, Osmund W.	8, Queen's Road, Rock Ferry
Jones, J. C., ...	82, Windsor Street, Liverpool
Jones, J. D., ...	72, Harrowby Street, Liverpool
Jones, R. Hughes, ...	Old Castle Blds., Preeson's Row, Liverpool
Jones, R. T., ...	21, Church Street, Egremont, Cheshire
Leslie, Miss L.	89, Avenue Road, St. John's Wood, London, W.
Lewis, A. E., ...	Longton Villa, Rainhill
Lewis, George	81, Everton Terrace, Liverpool
Lister, R. F., ...	41, Deane Road, Liverpool
Littlewood, T., ...	Vale Road, Woolton
Logeman, Willem S., Lit. Hum, Cand. M.R.C.P.	Newton School, Highfield, Rock Ferry, Cheshire
Mannington, H. T.,	40, Rumney Road, Kirkdale, L'pool
Marrow, Fred., ...	20, Boundary Street, Liverpool
Martin, William., ...	Station View, Yew Tree Rd, Walton
Miles, Charles E., ...	57, Willow Bank Rd., Higher Tranmere, Cheshire
Miles, William H., ...	3, Clifton Road, Birkenhead
Moore, C. Clifton, Jun... ..	125, Chester Rd, Hartford, Northwich
Moore, Miss Emily	123, Richmond Row, Liverpool
Moore, T. J., C.M.Z.S... ..	The Museum, William Brown St. Liverpool
Morgan, C. H., ...	72, Bank Road, Bootle
Morris, John	40, Wellesley Road, Liverpool

Morris, Mrs. John	40, Wellesley Road, Liverpool
McCully, R., ...	88, Wordsworth Street, Liverpool
Owen, William	4, Comus Street, Liverpool
Plastow, James	169, Great Homer Street, L'pool
Pratt, Miss E., ...	15, Alt Street, Liverpool
Quilliam, Arthur, ...	Port-e-chee, Braddon, Isle of Man.
Quilliam, W. H., ...	49, Bufford Road, Liverpool
Reade, T. Mellard, C.E., F.G.S., .. F.R.I.B.A.	Park Corner, Blundellsands Lancashire,
Robins, G. J., ...	Ashton Cross, Newton-le-Willows
Robson, George	66, Roscoe Street, Liverpool
Ricketts, Charles, M.D., F.G.S., ..	22, Argyle Street, Birkenhead
Roberts, J. Meredydd	20, Lowther Street, Liverpool
Roberts, Robert	9, Northumberland Terrace, L'pool
Roughsedge, W. H., ...	Church Street, St. Helens, Lancashire
Rowlands, T. V.	89, Duke Street, Liverpool
Rundell, T. W.	Litherland Park, Liverpool
Sharpe, Granville H., F.C.S., ..	College of Chemistry, 96, Duke Street, Liverpool
Scott, George..	131, Falkner Street, Liverpool
Semmons, William	57, Gracechurch Street, London, E.C.
Simpson, L. C., ...	Falkland Road, Egremont
Shilston, Capt. H. P., ...	1, Saltoun Terrace, Seacombe
Shilston, Mrs. H. P..	1, Saltoun Terrace, Seacombe
Shilston, Thomas, M.I.N.A., ..	The Avenue, Sunderland
Shilston, Mrs. Thos., ...	The Avenue, Sunderland
Smith, Edward	15, Upper Parliament Street, L'pool
Smith, W. M. D., ...	1, Dale Street, Liverpool
Storey, John	27, Gibson Street, Liverpool
Tate, A. Norman, F.I.C. ..	9, Hackins Hey, Liverpool
Tate, Geo., Ph.D., F.G.S., ..	College of Chemistry, 96, Duke Street, Liverpool
Tate, John A., ...	College of Chemistry, 96, Duke Street, Liverpool
Tapscott, R. L.	41, Parkfield Road, Liverpool
Thomas, Hopkin	4, Cable Street, Liverpool
Taylor, H. B., ...	7, St. James' Road, Liverpool.

Walker, William H., ...	Botanic View, Smithdown Lane, Liverpool
Ward, Thomas	Northwich, Cheshire
Westcott, H., ...	94, Prince's Road, Liverpool
Williams, J.J.,..	19, Falkner Street, Liverpool
Williams, Miss L., ...	101, Duke Street, Liverpool
Williams, T.G., ...	Moss Bank, Croxteth Road, L'pool
Williams, T. H., ...	2, Chapel Walks, Liverpool
Wigzell, Miss M., ...	22, Russian Drive, Tue Brook Liverpool
Young, Henry..	12, South Castle Street, Liverpool

Proposed for election on 2nd October.

Barber, J. M.,..	85, Premier Street, Everton
Beasley, H., ...	20 Chesnut Grove, Wavertree
Biram, Benj., Assoc. M. Inst. C.E,	St. Helens, Lancashire
Conlon, Bernard	22, Mount Pleasant, Liverpool
Currie, Luke	3, Lord Street, Liverpool
Jones, W. A., ...	32, Laurel Road, Edge Lane, L'pool
Jones, W. Joinson	7, Rhiwlas Street, Liverpool
Kissack, J. M., ...	18, Queen's Road, Liverpool
Marrat, Frederick P.	21, Kinglake Street, Liverpool
Rowett, Charles, ...	2, Verulam Street, Liverpool

Abstract of Proceedings

OF THE

LIVERPOOL GEOLOGICAL ASSOCIATION.

SESSION 1882-83.

2nd October, 1882.

The Annual Meeting was held this date, at the Free Library, MR. HENRY BRAMALL, M. INST., C.E., President, in the Chair.

The following were elected as Members:—Messrs. Benjamin Biram, Assoc. M. Inst. C.E.; H. C. Beasley; B. Conlon; Frederick P. Marrat; W. A. Jones; W. Joinson Jones; J. M. Kissack; Luke Currie; J. M. Barber; Chas. Rowett.

Proposed as Members:— Messrs. Alexander Ross, M.Inst. C.E., L. & N. W. Railway, Edge Hill; James Morgan, City Engineer's Office Liverpool; R. E. Jones, Arnold Street; and Frederick Padley, 15, Church Street, Liverpool.

DONATIONS.

"Proceedings," Liverpool Naturalist's Field Club, Session 1881-82,—*from the Club*; "On Meteorites," (Guide to the Collection, British Museum) by L. Fletcher, Pamphlets by William Whitaker, B.A., F.G.S.:— "On the Red Crag," "On Subaerial Denudation, &c.," "Lists of Works on the Geology of Cornwall, of Cambridgeshire, of Wales, of Hertfordshire, of Hampshire;" "Report of Excursion of Geologist's Assoc., (London) to the North Downs;—*presented by the Author*; Reports of Committees on 'Erratic Blocks," and on "Circulation of Underground Waters," and Address by Prof. Etheridge to Geol. Sec., read at the Brit. Assoc., Southampton Meeting, 1882,—*presented by W. Whitaker, B.A. F.G.S.*

The Annual Report and Treasurer's Statement of Accounts were presented to the Meeting, and the Officers for the Session 1882-83, were elected.

The following is an Abstract of the

PRESIDENT'S ADDRESS.

In the pursuit of knowledge it is useful at convenient times to pause and look back upon the progress already made, to consider what has been done by fellow-workers in one's own special branch of study, and to lay down lines on which we may proceed ever onward with renewed diligence to that success, which is the assured reward of patience and perseverance. Such a convenient opportunity is presented to us by this the Annual Meeting of this Association, and in looking back to the work accomplished in the past session, it will be useful, first to consider Geology in its broader bearing, and to see what study has been devoted to the forces now at work in modifying the form of the Earth's crust.

Mr. Reade, in an eloquent paper on Rivers, pointed out the effects of subærial denuding forces, coupled with the transporting power of Rivers, in scooping out valleys, giving as a notable instance, the peninsula of India, where valleys 4600 feet deep have been scooped out of a flat table-land. The difficulty of grasping the immensity of time required has given rise to the idea of a "Pluvial Period,'" brought forward by Mr. Tyler, who assumes that the rainfall during that period was 720 times greater than now, but this seems to be only avoiding the difficulty, for whereas we see before us the stream capable *in time* of doing the work, we have no proof that atmospheric conditions ever differed very greatly from those now prevailing. The plutonic forces were brought under our notice by Mr. Clague in his able paper on Volcanoes, which was chiefly descriptive, and by Mr. Brennan, who dealt in a very masterly succinct style with all the theories which have been at various times brought forward as explanatory of Volcanic Energy, including the latest one started by Professor Prestwich.

Chemical Geology has received a considerable share of attention. Dr. George Tate, early in the session, in a paper on the formation of Minerals, shewed by the evidence of pseudomorphs that aqueous agencies have been the principal and most active in the production of mineral crystalline forms. His paper was illustrated by a very remarkable collection of pseudomorphous forms of various minerals; and in the discussion which followed some interesting facts were mentioned relating to the modern formation of minerals, and the effects of great pressures in modifying the forms of various substances and even producing chemical change. Mr. A. Norman Tate in his paper on Chemical Action in Relation to Geological Change pointed out the great power of carbonic acid when dissolved in water to produce changes in rocks and especially in limestone rocks, and this our members subsequently had an excellent opportunity of seeing on the occasion of our visit to Poole's Cavern, at Buxton. In a subsequent communication Mr. Tate described how the Ferruginous Bands, which are so common in the rocks of this neighbourhood, owed their existence to the same agency, an instance of which he gave near Storeton. As throwing light upon the absence of animal remains, in rocks largely impregnated with Iron, Mr. Clague drew attention to the effects now being produced by the iron brought down in solution by the River Neb at Peel. Mr. Semmons, in a note on a Cornish Beach, described the recent formation of copper carbonates, by the reaction of the carbonate of lime in the comminuted shells of which the beach is composed, upon the sulphate of copper brought down in solution by a small rivulet flowing from some disused mine workings, a fact which may help to explain the presence of the copper carbonates in the Triassic sandstones at Alderley Edge.

Mineralogy has been treated of by Messrs. Mannington, Roberts and Miles. The former read an excellent paper on Iron Pyrites, since reprinted in the *Mining Journal*. Mr. Robert's paper on Salt was full of valuable information, which the Members supplemented by their visit to the Witton Hall

Rock Salt Mine at Northwich, and Mr. Miles conveyed to us a large amount of instruction of the most interesting character, relating to Diamonds.

Palæontology was brought under our notice by Mr. Shilston, who, in his paper on Fossil Footprints, shewed how animals long passed away, and of whose bodies no trace is found, have yet left "footprints on the sands of time," by which we are enabled to learn how rich must have been the fauna even in Triassic times. In connection with this subject may be mentioned the researches of the Swedish Naturalist, Herr Nathorst,* who, by direct experiment, has shewn that the so called Algæ of the Cambrians, are really tracks, "footprints," of Crustaceans, Annelids, and Molluscs; and that the so-called *Eophyton* of the Lower Silurians, is probably the "track" of a jelly-fish. Mr. Auden, in a Paper on Fossil Horses, drew attention to the more recent discoveries in America as bearing upon the now popular theory of Evolution.

The *Field work* of the Association during the past session has afforded to our members opportunity of acquiring a practical acquaintance with all the Formations occurring in this vicinity. Mr. George early drew our attention to an excellent section of the Drift Deposits, to be seen at Garston; and, subsequently, a visit was paid to the Linacre Gas Works, where a section was inspected extending through the whole drift and into the underlying Red Rock. Nothing was seen to support the so called tripartite division of the Boulder Clay, and, on a subsequent occasion, the Boulder Cliffs at Dawpool were examined, under the guidance of Mr. D. Mackintosh, F.G.S., with a like result. The Upper Red Marl or Saliferous series was studied on the occasion of our visit to Northwich, and, later in the season, a section in the lower Keuper, at Wallasey, was visited, where curious phenomena of cross and false bedding, and possibly contortion, are to be seen. Also Flaybrick Hill, where, on the surface of the Rock, was an exposure of ice action such as is very rarely visible; while at Bidston the basement beds of the Lower Keuper were studied, *At Beeston* the junction of these basement beds with the

*Geol. Mag., 1882, p. 22.

Upper Bunter was clearly noted ; at Hilbre Point the Pebble Beds were well seen, and, Mr. George pointed out some glacial striæ bearing N. and S., which had not previously been discovered in this part; and at Burton Point, the superposition of the Pebble Beds upon the Lower Bunter was very distinctly observable.

Passing over the Permians, which the Speaker has long been of opinion are absent in this neighbourhood, an opportunity was afforded for the study of the Coal formation in the visit paid by the Association to the Sankey Brook Collieries. The Yoredale Shales and Grits and the Carboniferous Limestone was seen to great advantage at Buxton, where also the effects of intrusive igneous rocks were very apparent.

Further practical work was accomplished when the Association visited Owen's College Museum, and Prof. Boyd Dawkins most courteously received our members, took great pains to explain the arrangements, and afterwards conducted the party over the College, and shewed the splendid appliances there available for teaching Science. The Museum of the Chester Society of Natural History was also visited, and our Members were received with the utmost kindness by Mr. G. R. Griffith and Dr. Stolterfoth.

Looking now beyond the limits of our own Association, to see what, during our past session has transpired in connection with Geological Science, our attention is first arrested by the great loss sustained in April, of this year, in the death of the late Charles Darwin. Perhaps no writer has left a greater impress on Modern Science, and from the publication of his "Origin of Species" in 1859, may be dated a new era of thought on all palæontological questions. Probably no book published in this century, has caused a more profound sensation, or given rise to more controversy, much of the bitterness of which would no doubt have been avoided, had all, who chose to call themselves his followers, imitated Mr. Darwin's patient, painstaking research, and close observation of facts,

and stated their results, and the inferences they drew therefrom, with the charming *naivetè*, and modesty, of their illustrious leader.

Archæan Geology, as the study of the lower formations antecedent to the Cambrian has been termed, has attracted great notice recently. Professor Sterry Hunt proposed the following classification of these rocks in America, where they are enormously developed :—

1. KEWEENIAN, or Copper bearing Series of Lake Superior.
2. TACONIAN.
3. MONTALBAN, or Mica Schist Series.
4. HURONIAN, or Green Mountain Series.
5. NORIAN, or Labradorian.
6. LAURENTIAN.

and on his recent visit to England he stated that he had identified the Pebidian of Dr. Hicks with his No. 3 and part of No. 4 ; Dr. Hicks' Arvonian with the lower part of No. 4 ; and the Dimetian and Lewisian with the Laurentians of Canada. These ancient formations cover the greater part of Anglesea, and it is to be hoped, that, during the present session, we may be favoured by some of our members with papers giving the results of the most recent researches in them.

Much new light has also been thrown upon the relations of the members of the Trias, and Dyas, (or Permian), and their classification, and, as the former system so largely constitutes the solid geology of our district, the subject might be very profitably discussed by us, and a paper on this subject would be a very desirable addition to our coming transactions.

The International Geological Congress has recommended the following terms for universal adoption :—

Divisions of Sedimentary Formations.	*Corresponding Chronological Terms.*	*Examples.*
Group.	Era.	Palæozoic GROUP or ERA
System.	Period.	Silurian SYSTEM or PERIOD
Series.	Epoch.	Ludlow SERIES or EPOCH.
Stage.	Age.	Aymestry STAGE, or AGE.

They have also recommended a scale of colours, based on the solar spectrum, beginning at the Violet end, for the Trias, and finishing with the Yellows, for the Tertiaries, the colours for the Palæozoic groups being reserved for consideration by the Map Committee: and they have further decided to publish a Geological Map of Europe, on a scale of about twenty-five miles to an inch. The mere finding of terms appears to be but a small matter, but the proposed colours offer no advantage over the chaste and elegant ones adopted by our own national survey, and for our purposes, concerned as we chiefly are, with districts already mapped by that survey, the Speaker suggested that we cannot do better than adhere to those hitherto adopted.

Geological Literature has been enriched by several notable works published since our last annual meeting. Of the long promised work by Mr. Bauerman on Mineralogy, the first part, dealing with Crystallography and the Physical and Chemical properties of Minerals has appeared. It is a very complete treatise on these branches of the Science, and the second part, on Descriptive Mineralogy, will be awaited with great interest. Professor Judd has issued his work on Volcanoes which amply justifies the high expectations to which his previous papers on this subject had given rise; and certainly no Geological library should be without this book. There have also been published De Rance's "Water Supply of England and Wales;" "Harrison's "Geology of the Counties of England and Wales," "Heddle's "Geognosy and Mineralogy of Scotland," (several of the northern counties have been issued), Ball's "Economic Geology of India," and the "Life, Letters, and Journals of Sir Charles Lyell," with others, of which time does not permit so much as to give the titles. Some of those named have already been added to our Library, and it is hoped that by the liberality of our members, and friends, we may soon possess them all.

In concluding, the Speaker pointed out that the success hitherto attained by this Association, was due to the cordial co-operation of the Members in supporting the Officers in their sometimes arduous labours, and to the spirit and enthusiasm

of those Members especially who had brought forward such a varied, able, and interesting, series of papers, and he urged that it is only by a continuation of this earnest working spirit, that the future success of the Association can be assured, and that the coming session, when looked back upon from the standpoint of our next Annual Meeting, may afford as good ground for congratulation as does that which is now "numbered with the years that are told."

Abstract of a Paper read—

"NOTE ON THE ARTIFICIAL PRODUCTION OF THE DIAMOND."

By Willem S. Logeman, Litt. Hum. Cand., M.R.C.P.

The artificial production of the Diamond having been referred to in a Paper recently read before this Association,* the following account of some experiments bearing upon the subject, performed by Professor W. M. Logeman, of Haarlem (the father of the present writer), may be of interest.

Those who have read the descriptions of the experiments of Ganal, Mactear, and Hannay, are not likely to doubt the possibility of "making diamond." There is, however, a great difference between making *diamond* (*i.e.* the material), and making *diamonds* (*i.e.* crystals of carbon of such a size as to possess a commercial value.) Until recently most persons were disposed to look upon attempts to produce diamond much in the same light as upon the old experiments of alchemists to make gold. In the former case it is not a question of transforming one element, or reputed element, into another, but merely of causing carbon, which exists abundantly in one form, to assume another—rarer—molecular structure. Looked at from this point of view it would seem that, instead of being impossible, the experiment ought not to present any great difficulties. However, the peculiar chemical and physical properties of carbon are such that in practice these difficulties are almost insurmountable.

*"Diamonds," By Charles E. Miles. *Vide* Transactions. Vol. ii. page 92.

There are various methods of causing crystallization, for instance :—

FIRST.—*Solution of the material to be crystallized in a liquid and slow cooling, or evaporation of the solvent.*

This method fails in the case of carbon, because there is no liquid known which will dissolve ordinary carbon without combining chemically with it.

SECOND.—*Melting of the material and slow cooling.*

Carbon, no doubt, is molten in the electric arc, as the carbon points in the lamps clearly show; but the essential condition of success, *slow* cooling, cannot be fulfilled.

THIRD.—*To evaporate the molten material, and allow the vapour to recondense against a cooler surface.*

Iodine and sulphur can easily be made thus to yield crystals. On one occasion after an experiment with an arc-light, which had lasted so long that the surrounding globe had become, in consequence, unusually hot, my father noticed among the amorphous carbon which covered the glass many hard and sharp grains. These were collected, and showed themselves to the naked eye to be minute white or grey specks. It was found, however, impossible to separate them from the adherent black particles of carbon. The microscope showed nothing definite, and the only ground for supposing these bodies to be "diamond" was that, when rubbed between two glass plates, they scratched these very clearly.

FOURTH.—*Slow evaporation by electro-lysis from a chemical combination.*

This was Ganal's method in 1850, and was also the way my father attempted in the following experiment.

The apparatus of Donny and Mareska for the liquefaction and solidification of carbonic acid had been recently acquired by the Teyler Museum, at Haarlem, and permission was readily granted by the Director, Professor van Breda, to use the

apparatus in order to subject some liquified-carbonic acid t slow electro-lysis by means of two platina wire electrodes Great difficulties were met with in the preparation of glas tubes through the walls of which wires had to be fixed an the glass molten to close around them strongly enough t resist the pressure of the partially liquified carbonic acid at temperature of 15° C. After repeated failures two such tube were prepared; one was placed vertically under the leaden bell shaped cover and the two wires brought into connection with an electric battery of 6 Daniel cells. The needle of a rheoscop showed that, although a bad conductor, the carbonic acid di allow a current to pass, which soon began to diminish (*i.e.* began to experience greater resistance). An explosion fol lowed, which concluded that experiment. A second tub met with the same fortune, and a third was prepared of nar rower bore and with thicker walls, which promised greate success. The current sent through it was of only one cell. In this tube the resistance was found to be evidently increasing and after some eight hours the inner resistance equalled the force of the cell: no current did pass. The apparatus wa then left undisturbed until the next morning. On being then examined, and the leaden cover removed, the tube was dis covered whole, containing liquid carbonic acid in the lowe half, and there was no evidence of anything having taken place. It seemed likely that one of the electrodes had been covered with a thin layer of crystallized carbon—for it wa clear that some resistance, which did not previously exist, had arisen, but inspection through the glass showed nothing. It was therefore decided to break the tube, but upon this being attempted, the tube exploded and broke into small fragments The electrodes were bent and almost broken. The negative one appeared to sight and touch somewhat smoother and more shining than the other. Both were immersed in diluted sul- phuric acid, and connected with a battery of 3 cells. What had been the positive one soon covered itself with small bubbles of gas, but the negative one *only on those places which had been bent.* This clearly pointed at the wire having been covered

with some non-conducting medium. It was afterwards a matter of regret that the thickness of the wire had not been carefully measured by the micrometer, before,—as was done—holding it in a spirit flame. One of the observers thought he saw something come off the wire ; the other did not observe this. Anyhow, after cooling, the wire behaved as the other electrode in repeating the experiment of analysing water.

There had, then, been some covering. What was it ? To say that it was crystalized carbon would only be right if it could be said that the carbonic acid employed had been chemically pure. And who could say that ?

Though the experiment must be called a failure, yet the acquired knowledge of what will, no doubt, always be the way of producing pure crystallized carbon by means of the electric current, was a reward for the trouble which the experiments had entailed.

LIVERPOOL GEOLOGICAL ASSOCIATION.

Field Meeting, 21st October, 1882.

The works in connection with the opening of the Edge Hill Railway Tunnel were visited, by the kind permission of Mr. Henry A. Dibbin, M. Inst., C.E. (Chief Engineer). On arrival at Edge Hill, the party were met by Mr. T. S. Keyte, (Assistant Engineer), and Mr. Nicholls, who conducted them through the works. The rocks exposed belong to the formation of the Pebble Beds and Lower Bunter; and, in a cutting near the University College, the Keuper Sandstone, which has been thrown down by a fault, was also observed.

6th November, 1882.

At the Ordinary Meeting held this date, at the Free Library, Mr. Henry Bramall, M. Inst., C.E., President, in the Chair, the following were elected as members:—Messrs. Alexander Ross, M. Inst., C.E., James Morgan, R. E. Jones, and Frederick Padley.

Proposed as Members:—Messrs. Harold Kirkmann, 1, Egerton Place, Liscard, Cheshire; Benjamin Swinton Biram, B.A., Sherdley, St. Helens; J. M. Williams, The Hawthorns, Hawthorn Road, Bootle.

DONATIONS,

Abstracts Proc. Geol. Soc., Lond., March to June, 1882,—*presented by Mr. G. H. Morton, F.G.S.*; Green's "Physical Geology,"—*presented by Mr. George Lewis*; Dawson's "Chain of Life in Geological Time,"—*presented by Mr. W. H. Miles.*

The following Communications were given :—

I.

"On the Stem of a recent Tree-Fern."

By Frederick P. Marrat.

The specimen exhibited was found in a wet gully in Australia, and possessed much interest on account of its resemblance to the fossil *Caulopteris* of the Coal Measures.

II.

"Some Observations on Ammonites."

By Frederick P. Marrat.

[The following are the Secretary's Notes of Mr. Marrat's communication] —

ON AMMONITES.

The Speaker stated that if, ten years ago, he had been asked : What was an Ammonite ? he would have readily answered that it was the shell of a cephalopodous mollusc allied to the Nautilus. The accumulated evidence regarding this animal is, however, of a very perplexing nature, as many circumstances have transpired, rendering the lines of affinity between the Nautilus of to-day, or the associated fossil species of the Carboniferous, Lias, or Chalk periods, all that the geologist or zoologist could have wished them. His answer now must, therefore, be reserved. One of the principal reasons for keeping the two genera distinct is the presence in the Ammonite of an operculum, known as the *trigonellites* or *aptychus*, and other thin but doubtful organisms that have been found in various parts of the outer chamber of these cephalopods.* The operculum has been found in the following Ammonites :—

A. lingulatus.

A. subradiatus.

A. falcifer (where it is corneous or chitinous).

A. bifrons Brug., (Corneo-calcareous).

A. Sternaspis.

* In the Museum of Munich there are one hundred examples of Ammonites, each accompanied by its aptychus, five of which are *in situ.*

So many conflicting opinions regarding the animal and its operculum have arisen within the last few years that the matter is rendered doubtful. Some zoologists express the opinion that the Ammonite was an internal shell, resembling the Spirula; others assert that the animal was pelagic and floated about in mid-ocean. Others, again, have supposed that the operculum, instead of being a protection to the animal and serving as a lid to close the aperture, was an internal organ peculiar to the female Ammonite, although no analogy can be found in Nature to support such a statement. There are still some zoologists who altogether ignore the trigonellites as belonging to the Ammonite, but consider it to be the valve of a Cirriped. Mr. Sowerby thought that it resembled some of the palatal teeth of fish. Sclotheim considered it to be a bivalve, allied to the genus Tellina; and Mayer gave it as the internal shell of some undetermined mollusc. We are now tolerably well satisfied that *trigonellites*, or *aptychus*, is the opercular valve of the Ammonite.

A distinction is usually made between the Nautilus and the Ammonite in the position of the siphuncle. The speaker pointed out that the Nautili had simple sutures, but many of the subdivisions are found with slightly wavy, curved and even sinuous sutures, so that this character is by no means permanent. The situation of the siphuncle, also, cannot be strictly relied upon, as we find that it may differ in position in the young and adult state of the same species.

Another divergence was also mentioned, and one that at first sight might have had its origin in a mere accident. Thus a small stone became fix d between the whorls of a very young mollusc, which had the effect of throwing the whorls out of the discoidal line, and thus would a shell of a trochiform shape be produced. Such in reality are the shells of the genus *Helioceras* passing into the elongated spiral of the Turrilites. In the deformed and repaired shells in the Gaskoin Cabinet, these stones, composed of quartz and granite are still remaining in the joints between the whorls of the shells.

The whole evidence is in favour of a passage from the

Nautilidæ into the Ammonitidæ, and it also points to the probability that the Goniatites, Clymenia, and all the divisions into which they have been separated are simply branches of one tree. Again, there appears considerable likelihood of the complex Orthoceratidæ being allied to the Belemnitidæ, passing through the fossil genus Spirulirostris into the recent Spirula.

The sloping sides of the hood of the the Nautilus, when closed over the head and tentacles, would require an operculum with a central hinge to protect the enclosed animal. The *trigonellites*, or *aptychus*, is just such an instrument. But, because we find opercula in one, two, or even several species of Ammonites, we must not jump to the conclusion that all the species were furnished with these appendages. They may have been confined to a limited number of forms, and from the comparatively rare occurrence of these fossil opercula, we may infer that such was the fact. Not only calcareous but corneous opercula have been found. Judging from analogy, the speaker inferred that we may safely conclude that such species as resembled the Nautilus—inhabiting deep water (from 200 to 300 fathoms,) walking over the bottom of the ocean with the shell raised like a *helix* or *planorbis*, and provided with a thick hood to envelope the head and tentacles,—were without opercula; whilst others, which inhabited shallower water and were more liable to be attacked by fish or other enemies, were provided with this hinged lid.

The following are the divisions occupying the intermediate position, and showing the various degrees of curving, between the Nautili and the Orthoceratites.

Actinoceras.	*Aphragmites.*	*Ascoceras.*
Aganides.	*Aploceras.*	*Bathmoceras.*
Andoceras.	*Aptoceras.*	

Aturia, *Aulacoceras*, and transition forms between the Nautilidæ and Belemnitidæ.

Cameroceras.	*Gonioceras.*	*Nothoceras.*
Campulites.	*Gyroceras.*	*Phragmoceras.*
Clossoceras.	*Hercoceras.*	*Piloceras.*
Clymenia.	*Hortolus.*	*Subclymenia.*
Cryptoceras.	*Koleoceras.*	*Thoracoceras.*
Cyrtoceras.	*Lituites.*	*Trochoceras.*
Gomphoceras.	*Nautiloceras.*	*Trocholithes.*

The following genera are found between the discoid Ammonites and the straight Bacculites, Bactrites, &c.

Ammonoceras.	*Clydonites.*	*Helioceras.*
Ancyloceras.	*Crioceras.*	*Ptychoceras.*
Anisoceras.	*Goniatites.*	*Scaphites.*
Ceratites.	*Hamites.*	*Toxoceras.*
Choristoceras.	*Hamulina.*	

The following genera are between the discoid Ammonites and the turrited Turrilites.

Turrulites	*Boblayi.*	*Heteroceras.*
,,	*Coynarti.*	*Helicoceras.*
,,	*Valdani.*	

AMMONITES.

In the Free Public Museum, Liverpool, is a very fine example of an Aptycus, imbeded in the Lithographic-slate of Solenhofen. The two valves are as distinctly granular as the operculum of the Turbo margaritaceus. One of

"AMMONITES."

NOTE.—The enclosed slip forms an addendum to Mr. Marrat
…r on the above subject, and can be inserted in the Transactions.

they were not free like those of the Gasteropoda, but were partly imbeded in a cartilaginous operculiferous lobe, that fitted the sides of the shell like the wavy margins of the hood of the Nautilus.

I cannot imagine of what use a large outer chamber, furnished with a protective operculum, could possibly be to a mollusk like the Ammonite if it were inclosed in fleshy or animal matter. The genus Spirula has no species in it having an outer chamber like the Nautilus or Ammonite, or any operculum. No recent mollusk, either Cephalopod or Gasteropod, has yet been discovered having an internal shell with its aperture closed by a strong shelly operculum.

Knowing nothing about the animal of the Ammonite, we may suppose it to have been either dibranchiate, tetrabranchiate, or partaking of the characters of both, but until some positive evidence is obtained it will be simply supposition.

AMMONITES.

In the Free Public Museum, Liverpool, is a very fine example of an Aptycus, imbeded in the Lithographic-slate of Solenhofen. The two valves are as distinctly granular as the operculum of the Turbo margaritaceus. One of the most interesting facts connected with these valves is their resemblance to the thick granular hood of the Nautilus pompilius. The shells and opercula of mollusca are in the greatest perfection in the middle stages in the life of the animal, being incomplete when young and liable to injury and deformity when they are old. The opercula of recent mollusca are very liable to injury either from being eroded or worn by friction, and it is only occasionally that a really fine example is obtained.

These valves of the Trigonellus or Aptycus, appear to have belonged to an Ammonite entombed when in the prime of life, before any circumstance had occured to injure them in any way. From the appearance of these two valves they were not free like those of the Gasteropoda, but were partly imbeded in a cartilaginous operculiferous lobe, that fitted the sides of the shell like the wavy margins of the hood of the Nautilus.

I cannot imagine of what use a large outer chamber, furnished with a protective operculum, could possibly be to a mollusk like the Ammonite if it were inclosed in fleshy or animal matter. The genus Spirula has no species in it having an outer chamber like the Nautilus or Ammonite, or any operculum. No recent mollusk, either Cephalopod or Gasteropod, has yet been discovered having an internal shell with its aperture closed by a strong shelly operculum.

Knowing nothing about the animal of the Ammonite, we may suppose it to have been either dibranchiate, tetrabranchiate, or partaking of the characters of both, but until some positive evidence is obtained it will be simply supposition.

LIVERPOOL GEOLOGICAL ASSOCIATION.

4th December, 1882.

At the Ordinary Meeting, held this date, at the Free Library, Mr. Henry Bramall, M. Inst. C.E., President, in the Chair, the following were elected as Members :—

Messrs. Harold Kirkmann, B. Swinton Biram, B.A., and J. M. Williams.

Proposed as Members :—

Messrs. H. C. Banister, Rossett Road, Crosby ; Wm. H. Davies, jun., 55, Great Newton Street, Liverpool.

DONATIONS.

Geikie's "Geological Sketches"; Huxley's "American Addresses,"—*presented by Miss L. Williams*; Geikie's "Text Book of Geology,"—*presented by Mr. T. R. Connell*; Ball's "Economic Geology of India,"—*presented by Mr. T. S. Hunt*; Medlicott and Blandford's "Geology of India,"—vols. I and II, with large Geological Map,—*presented by Mr. William H. Walker*; Darwin's "Voyage of the Beagle." Hugh Miller's "Cruise of the Betsy,"—*presented by Mr. Charles E. Miles*; Conybeare and Phillip's "Geology of England ;" Page's "Geology" and "Illustrated Geology,"—*presented by Mr. F. P. Marrat*; "Transactions," Parts 1 and 2, vol. 17, Manchester Geological Society,—from the Society.

The following Paper was read :—

"SOME OBSERVATIONS ON THE DARWINIAN THEORY OF EVOLUTION OF SPECIES,"

BY HUGH FERGIE HALL, F.G.S.

I have been asked to give you a Paper on the theory of the Origin and Evolution of Species, as proposed by Mr. Darwin.

Before entering on this subject, I desire to make some general observations which appear to me to be necessary in discussing this theory. And I would disclaim any merit but that of presenting to you in as succinct a form as possible, views which have commended themselves to my own mind as tending to show that that theory is not worthy to be regarded as scientifically reliable.

In the first place I would remind you, that *brain power* in different individuals, is shown not only in greatly varied degrees, but in very varied forms. In some, it takes the form of being able to make accurate observations of the phenomena that come under their notice, and in others of the power to sort and classify such phenomena. Others again, it enables to deduce from the records of such phenomena, the causes to which they are due. Each in his own particular sphere may be great, but it is rare to find men who combine in their own persons all these varieties of power. Hence it is not always safe to receive the reasonings of an observer, any more than to accept the observations of a reasoner, whose knowledge of phenomena may be insufficient.

None can be more fully sensible than myself of the dignity of science, when that is as it should be "truth ascertained—that which we know;" and when it is followed by its disciples in a right spirit, viz.: the pursuit of knowledge or truth for its own sake. To be one of such a class of men is to my mind one of the noblest aspirations that can take hold of the mind and heart of any man, and to attain a position among them I take to be one of the greatest honors to which the noblest minds can attain. But while I hold this I have had so strongly forced upon my attention some views called scientific in the present day, which seem to me to tend to the degradation of true science, that I feel sure you will receive with attention what I conceive to be "The attitude in which scientific truth should be received," in order, if possible, that we may guard against mistakes which, though easily fallen into, frequently take generations to undo. That the *truth* in physical science, as in other things, will eventually prevail, I for one

have not the slightest doubt; but the way in which new views, whether of phenomena or of reasoning, are received, must largely influence not only the acceptance of ascertained truth by the non-scientific world; but the time when such truth will prevail will arrive more rapidly, or be delayed, by the course which scientific men pursue in their own acceptance and promulgation of it.

I need hardly remind you that Science is the knowledge of facts, relating to the phenomena of any given subject. In a larger sense it includes philosophy, which is the knowledge of the causes of such phenomena, the general principles and laws which underlie them. It is evident therefore that there may be two sources of error; first, the acceptance of so-called facts stated upon imperfect observation and experience; and second, the acceptance of causes, principles or laws deduced from such imperfect or careless observation, or from an insufficient acquaintance with the facts from which such laws are deduced, or others modifying them. Men of the most exalted powers, both of observation and reasoning, are always liable to error, both from imperfect knowledge of facts and imperfect powers of reasoning. Following upon these there are other sources of error, among which may be mentioned the delight which men of lively imagination feel in allowing it too free play, without the restraint of accurate reasoning; and the enjoyment we all find in receiving new ideas, which leads to the acceptance of the "new" (if it have any show of reasonableness) without taking the trouble to carefully investigate whether the new ideas will stand the test of observation, experience and reason. It becomes us then most carefully to guard against all these causes of error, inasmuch as we know that the accumulated facts are yet few compared with what we may hope to know; and in this condition of things, we are more liable to the abuse of the imagination to which I have referred. Knowing that the opportunities of any individual observer are necessarily few, and the time during which his individual study of a science can be carried out is short, even if he attain to the utmost limits to which the life of man

can stretch, it is much more delightful to allow the imagination to run riot, than to be content to wait for further light to the slow observation of new facts and the quiet thoughtful reasoning upon the whole range of facts, radiating most probably in numerous directions from any given centre of thought, from which alone we can expect true causes to be ascertained.

The processes of mind are so subtle, and so largely influenced by preconceived opinions, derived from many quarters —historical, religious, mental, personal—that it is a matter of very great difficulty to overturn a false principle. And the difficulty is greater because these false principles take hold of a much larger circle of the human race than the scientific class from whom they sprung. Multitudes receive the teachings of the leaders of science of their day, who have themselves little or no conception of the foundations of the opinions they hold; and, from the very indefiniteness of their views, they are always ready to put aside a difficulty with the reflection, that they don't know enough about the subject to be sure that it is a difficulty, and that the propounder of the opinion, which may seem erroneous, must have given such attention to the subject, that the probability is that their difficulty would turn out no difficulty if they could only use his greater knowledge in looking at it.

We also find errors frequently arising from the endeavour to account for many different results from *one cause* alone, forgetting how many influences may be brought to bear even upon one result, and how largely many forces influence and modify one another. "One key will not fit every lock" is a useful proverb for the followers of physical science to bear in mind, if they desire to avoid mistakes in themselves and others.

But I have said that, among other sources of error, may be mentioned the delight which men of lively imagination feel in allowing it free play, without the restraint of accurate reasoning; and the enjoyment found in the reception of new ideas, which leads to the acceptance of the "new" if it have any show of reasonableness, without taking the trouble to carefully investigate whether the new ideas will stand the test of

observation, experience, and reason. The former explains the facility with which such theories may be propounded, the latter the readiness with which they may be received.

This I take to be *illustrated* in the Darwinian theory of Evolution as developed in his "Origin of Species," which appears to be one of the most remarkable exhibitions that has ever been given of the use (or shall I not rather say the abuse ?) of the imagination, in building up a theory which to my mind is so utterly defective in accurate reasoning, that the wonder is that so many scientific men have ventured to receive it. It seems to upset the evidence of design, and the arguments to be deduced therefrom as to the origin of life, and the being of an allwise, intelligent, and loving Creator and Ruler of the world. I shall endeavour, as well as I am able, first to give a short view of the theory and of the argument used to support it, and then to show where I consider its weakness and want of reliability lies.

The laws acting around us, says Mr. Darwin, are Growth with Reproduction—Inheritance which is almost implied by Reproduction—Variability from the indirect and direct action of the conditions of life, and from use and disuse—a ratio of increase so high as to lead to a struggle for life, and as a consequence to Natural Selection, entailing Divergence of character, and the Extinction of less improved Forms. Thus from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows.

His book opens by giving an account of Variation under Domestication, as illustrated by the domestic fowl, the pigeon, the ox, the sheep, the dog, &c. He asserts a difficulty in defining the difference between a variety and a species, and that species are only what he calls permanent varieties. He affirms that in the wild state variability is as constant from natural selection, as under domestication ; and that wide ranging, much diffused, and common species, vary most, and that the forms of life now dominant tend to become still more dominant. He affirms a struggle for existence not only between in-

dividuals of the same species, but between species widely differing from one another. From this struggle for existence he deduces that the fittest will survive—that is of individuals and races in whom advantageous variations have occurred.

He then discusses the difficulties of his theory—admits the absence or rarity of transitional varieties—admits the difficulty of accounting for the formation by modification of one animal from another having widely different habits and structure; or of accounting for the production of organs such as the tail or the eye; or of the acquisition of instincts such as that by which the hive bee forms its cells; and of accounting for the sterility of hybrids while the produce of varieties remains fertile. From the imperfection of the Geological record he argues that transitional varieties may have been lost which would account for the gaps found in the line of descent by natural selection, but claims the element of prolonged time as allowing the possibility that in that element such changes as he admits are necessary to the stability of his argument *may* have taken place, and concludes that, as we know variations do take place within certain limits, it is possible to conceive them as permitting the derivation of species from species; and affirms that in his belief animals are descended from at most only four or five progenitors, and plants from an equal or lesser number. He adds " Analogy would lead me one step further, namely, to the belief that all animals and plants are descended from some one prototype. But analogy may be a deceitful guide."

And here I must remark that if there be one form of expression more common than another throughout his book—it is that" analogy leads him" to think, to believe, or to conclude such and such a thing.

Now, I shall yield to none in my admiration of Mr. Darwin as one of the most accurate and painstaking observers and collectors of facts relating to the phenomena of Physical Science. Nor would I for one moment question the evident sincerity and honesty of purpose which is exhibited in his writings. But, admiration of him as a scientist, and belief in his sincerity and

honesty of purpose, must not blind us to the inconsistencies and want of consequentiality which appear in his arguments. One of the great services that Darwin has rendered to Physical Science has been in checking the propensity to invent new Species, and in reducing the number of so-called Species by showing that many of them are only Varieties which may fairly come within the limits of Variation.

But, to discuss his position, one of the first necessities in the argument is a clear definition of the terms. This Mr. Darwin himself recognises; for he says:—"To discuss whether such forms are rightly called species or varieties before any definition of those terms has been accepted, is vainly to beat the air." But this is exactly what Mr. Darwin has failed to do. We look in vain in his book "The Origin of Species," for any definition of "Species." Indeed we cannot be quite sure from some passages whether such things as Species exist. "Hereafter," he says (at the close of his book), "we shall have to treat Species in the same manner as those naturalists treat Genera, who admit that Genera are merely artificial combinations made for convenience. This may not be a cheering prospect, but we shall at least be freed from the vain search for the *undiscovered and undiscoverable* essence of the term Species." Now, "essence" means being, and, in a limited sense, the qualities of a thing. We may well ask, then,—What can be thought of an endeavour to enquire into the origin of a thing, or of the reasonableness of giving it to the world, the being of which, on the author's own showing, is "undiscovered and undiscoverable," or, in the more limited sense, the qualities of which (which he has been discussing through no less than some 400 pages), are in the same condition. But we shall, as we go on, see that Mr. Darwin himself admits that there is such a thing as a "good and distinct Species."

Mr. Darwin tells us that he "looks upon the term Species as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not *essentially* differ from the term Variety, which is given

to less distinct and more fluctuating form.'' Now, I would say, surely " distinctness" and " permanency" are elements which may well justify the distinction given by naturalists to Variety and Species. But it is quite clear that Mr. Darwin himself, though repudiating the distinction, holds it to be a true one; though, by an interchanging and confusion of terms, he still desires to lead the mind to the belief that no distinction exists between these terms. For we find him saying :—" I look upon Varieties which are in any degree more distinct and permanent as steps leading to more strongly marked and more permanent Varieties, and these latter leading to a Sub-Species, and so to Species. Hence, I believe a well-marked Variety may be considered an incipient Species." Again, he says :— " It may be asked, how is it that Varieties, which I have called incipient Species, become ultimately *converted into good and distinct species*, which in most cases obviously differ from each other far more than do the Varieties of the same Species.'

Now, if there is no " essential diffierence" between Variety and Species, what is the meaning of such language as that " Varieties become ultimately converted into good and distinct Species" ? It is evident, therefore, that, after all, there is in Mr. Darwin's mind such a thing as a good and distinct Species, and that before Varieties can be recognised as such it is necessary to " convert," that is, change them from what they are into something else, which conversion, I venture to think, most of us would think constituted an " essential difference." But no such difficulty seems to have struck Mr. Darwin's mind, and I must leave it to him and to his disciples to reconcile his language. It seems to me plain that, in spite of his disclaimers, Mr. Darwin *feels* the reality of the difference which he attempts to disprove.

Now, the question arises, Is there no fixed boundary by which naturalists may distinguish Species? It is true that, when considering resemblance of form, many naturalists differ as to its importance as distinguishing Species. But there is one fixed natural boundary which all great naturalists have agreed to consider as constituting a plain mark, as distinguish-

ing Species from Varieties. I refer to the law by which the hybrid offspring of two races is invariably sterile among themselves. If this be found universally true (and Mr. Darwin admits it, for he says, "I doubt whether any case of a perfectly fertile hybrid animal can be considered as thoroughly well authenticated;" and further, "it is, perhaps, impossible to bring forward one case of the hybrid offspring of two animals, clearly distinct, being itself perfectly fertile." "I do not know of any well authenticated case of a perfectly fertile hybrid animal.") I say, if this be found universally true, what must we think of the theory which, professing itself unable to produce even *one* case to disprove it, assumes, giving it the element of indefinitely prolonged time, the *possibility* of that overstepping of the boundary of species, without which the further progress of the argument is stopped; and then, reasoning from that as a fact which it has merely assumed as a possibility, goes on to further lengths in the same direction. Science, as we have seen, investigates that which we know, and cannot deal with the unknown, and allows only inductive reasoning from facts, rejecting any theory that is unsupported by them, much more one which is at variance with them; and yet here we find one of our best scientists deliberately admitting that the facts are against him, and yet going on to argue as if they were in his favour. We may well ask for one single instance to be shown us of the development by natural selection of any one species from any other species; but Mr. Darwin, while admitting that he cannot point to one such mutation, thinks his assertion that it is a possibility is sufficient to settle its probability; and then, arguing from its probability, asserts that it is. From Analogy in the variability within the limits of species (which is admitted, but which we say, is confined by bounds which cannot be passed), he assumes the probability of variability beyond the limits of species—but we may well answer him with his own declaration that "Analogy may be an uncertain guide." In fact, as has been pointed out by one writer, his whole argument is one of the best commentaries on his own warning, in his "Naturalist's Journal of Researches," that

"he has found, to his cost, a constant tendency to fill up the gaps of knowledge by inaccurate and superficial hypotheses."

Again, as to the term "Natural Selection," which he puts forward as the means by which the presumed mutation of species into other species is produced, there are two difficulties in regard to it. In the first place, what is "Natural Selection?" what clear image or idea does it convey to the mind? and, in the next, assuming that there is such a thing, what evidence have we that such a power is either capable of, or does exert the influence he professes to find it able to exert. Now, as to the term itself, it implies that Nature (an Impersonality used to cover all being, animate or inanimate) has a power to choose how one plant may be fructified by another, or one animal may mate with another. If this be not the meaning, what is it? And I say, if this be the meaning, that the facts we see around us belie the truth of the assertion. Has the insect that carries the pollen from one flower to another the power of knowing exactly which flower produces the pollen which carried to another particular selected flower shall produce a variety with characteristics which shall beneficially raise it in the scale of being, so as as to enable it to weather the storm which shall destroy its fellows. Do we find, in fact, the most perfect males of a species "select" the most perfect females with which to mate. And if not, as we know it is not, then the terms employed are such as convey to the mind no definite conception. This leads me to the remark, that one of the great difficulties we have to encounter in comprehending Mr. Darwin's exposition of his theory, is the use of terms which constantly falsify each other. Thus he says—"If Natural Selection be a true principle, it will *banish the belief of the continued creation* of new organic beings, or of any great and sudden modification of their structure." In other words, Creation is a dream, if Mr. Darwin's theory be true, and Natural Selection is the *marvellous* power that supersedes it. And yet Mr. Darwin himself tells us in his argument as to the supposed formation of the eye, that "we may believe that a living optical instrument was thus formed as superior to one of glass as the works

of the Creator are to those of man." But, if Natural Selection is "to banish the belief in continued Creation," what works of the Creator can there possibly be which can thus be superior to those of man? Now, I am quite aware that Mr. Darwin has said "It has been often said that I speak of Natural Selection as an active power or deity. Every one knows what is meant by such metaphorical expressions and they are almost necessary for brevity. So, again, it is difficult to avoid personifying the word Nature, but I mean by nature only the aggregate action and product of many laws and by-laws, the sequence of events as ascertained by us." Now just let us examine this. Natural Selection and the Struggle for Existence are Metaphors. But Metaphors are not realities, have no powers, and can lead to no results. Yet Mr. Darwin is constantly ascribing to Natural Selection powers of the greatest magnitude and highest importance, as when he says "Natural Selection was intently watching each accidental alteration." "Natural Selection acts exclusively by the preservation and accumulation of Variations" &c. &c. Now according to himself, Natural Selection is but a Metaphor, an unreality; how then I would ask can that which is unreal have existence, or produce or control realities? Yet that is what Mr. Darwin would appear to wish us to accept.

To pass on to the results however of Natural Selection and the struggle for existence. Mr. Darwin enters into most interesting discussions as to Variations produced under domesticity by the Selection of Man, and these Variations are without doubt highly interesting and valuable. But I may be permitted to say that Variations which may be highly valuable to man, may be after all not intrinsically valuable to the animal or plant, on whom man's experiments are tried—in fact, so far from being valuable to enable it to prolong the Struggle for existence, may distinctly, when man's superintending care is removed, have quite an opposite effect. But after all the particularity of his descriptions of the results of this Variability, he is obliged to admit, that when such Varieties are left

to themselves, by man's care being withdrawn, their universal tendency is to *revert* to the original type.

Notwithstanding this admission however, Mr. Darwin proceeds to argue that such Variations when produced by Natural Selection may have through long periods of time, resulted in the production of "true and good species." But when he comes to discuss how one species has become transmuted into another, Mr. Darwin is utterly unable to give any single authenticated instance of such transmutation, and therefore is obliged most unscientifically, to build up his main theory by other theories without any foundation of known facts. Not only so, but to quote himself, he remarks "I am well aware that scarcely a single point is discussed in this Volume on which facts cannot be adduced, often apparently leading to conclusions *directly opposite* to those at which I have arrived." Again 'undoubtedly *many cases occur* in which *we cannot explain* how the same species has passed from one point to another." "We may account for the distinctness of birds from all other invertebrate animals by the belief that many ancient forms of life have been utterly lost." But he gives us no ground for such a belief. Why should we have such a belief? The only conclusion seems to be, because it is necessary to the truth of his theory. But he goes further than this; he says, "we may readily believe that the unknown progenitor of the vertebrata possessed many vertebræ." Why should we readily believe this? Here he demands that *at one step* an immense change has taken place, not only from a variety to a species, or from one species to another, but from species to the highest divisions by which naturalists distinguish faunal life. And yet when it suits his purpose, Mr. Darwin does not hesitate to tell us, that the changes by which variation has enabled four or five original forms to expand into the Vast Variety of animals now inhabiting the earth, have been of such a *slow, gradual, and almost imperceptible* character, that for the perfection of the eye alone, he claims millions of improved variations and as a necessity—millions of years for those variations to take place.

The inconsistency of the statements appears to me to be patent. When one class of difficulties arise, we must believe, (if we are to follow him), that at one time the longest periods are required for the development of a single organ, and at another that that which cannot be supposed to have been produced in this gradual manner, Natural selection, that wonderful impersonality, was able to accomplish at a stroke.

Now, Mr. Darwin says, " If my Theory be true, numberless intermediate varieties, linking closely all the species of the same group together, must assuredly have existed; but the very process of natural selection constantly tends, as has been often remarked, to *exterminate the parent forms and the intermediate links.*" " All the intermediate forms between the earlier and later states, as well as the original parent species itself, will generally tend to become extinct."

But it has been well pointed out that the Geological Record, (which Mr. Darwin regrets is so imperfect as not to support his theory), not only does not support his theory, but conclusively shows that at those epochs where great changes in animal and vegetable life occur in the history of the earth's strata, it is by no means true that we find a gradual upward change, prophesying as it were the actual change that next presents itself, but that at each of these epochs, the new races of animals and plants present themselves in the most gigantic and perfect forms, and in each case gradually die away until supplanted by other races more adopted for the altered state of being. Even Huxley, (in his address to the Geological Society, in 1862), says, " Obviously if the earliest fossiliferous rocks now known are coeval with the commencement of life, and if their contents give us any just conception of the nature and extent of the earliest fauna and flora, the *insignificant* amount of modification which can be demonstrated to have taken place in any group of animals or plants, *is quite incompatible* with the hypothesis that all living forms are the results of a necessary process of progressive development, entirely comprised within the time represented by the fossiliferous rocks." Hugh Miller points out that

"when the ichthyic form constituted the highest form of life," it was not the most degraded forms that swarmed in the early seas. "As if" (he says), "to prevent so gross a misreading of the record, we find in at least two classes of animals—the fishes and reptiles—the higher races placed at the beginning." So from other naturalists, we might go on to show that with birds and quadrupeds, where deepest in the strata the records of their existence are found, they show themselves in full development without the building up process, which, according to Darwin, would be necessary for their coming into existence. If there is any evolution evidenced here, it is the Evolution of the lesser from the greater, not the Evolution of the greater from the less.

Agassiz, a naturalist, confessedly of observant and mental powers equal to those of the great naturalist whose views we are considering, says—"The true principle of classification exists in Nature herself, and we have only to decipher it. The standard is to be found in the changes animals undergo, from their first formation in the egg to their adult condition." "But when we follow the embryological condition out in growth of the animals themselves, and find that, close as it is, no animal ever misses its true development, or grows to anything but what it was meant to be, we are forced to admit that the gradations which unquestionably unite all animals is an intellectual, not a material one." "So called varieties or breeds, far from indicating the beginning of new types, or the initiating of new species, only point out the range of FLEXIBILITY in types, which in the ESSENCE ARE INVARIABLE."

So far, then, I say that Mr Darwin does not support his theory of Evolution by known facts, but only by a series of supposed possibilities, which he gradually ranges as probabilities, and concludes by asking us to accept them as facts.

In regard to many other points of the theory which might have demanded our attention, the limits of this paper prevent any extended examination of them. A very brief summary of some few of these points is all I can hope to compass, and many will have to be dismissed with merely naming them.

Thus, in regard to the organic similarity of animals, (which if the theory be of such importance as is claimed, should certainly be one of the strong points on which it rests,) I must allow it to pass with Mr. Darwin's own admission, that "it is most difficult to conjecture by what transitions organs could have arrived at their present state." Well has it been said by a commentator on this point, "If even *conjecture* is at fault here, an instrument which in Mr. Darwin's hands has done such ample service, it must be utterly hopeless to ask for certainty; and if even *imagination* can do nothing how can we ask for a scientific exegesis."

Mr. Darwin further cuts away the ground from under himself by his remark, "that nothing can be more hopeless than to attempt to explain this similarity of pattern in members of the same class by Natural Selection, and the struggle for life." If he then is content to give up the attempt, I think certainly we may be excused if we follow his example.

Another of Mr. Darwin's formulæ involves the extinction of unimproved forms. But there are multitudes of cases to be quoted where this is not true. How many of the mollusca can be shown to have remained unchanged during the long periods of Geological time in which they are known to have existed, some even of the earliest remaining even to the present. If this theory be true, why have not these succumbed to the action of his law, as more improved species have come into existence. But on the other hand, how are we to reconcile with this theory the constant appearance of new *types*, the Ammonites for example, which came into being and have become extinct within very limited and definite zones.

Another point I may mention is this (and it has never so far as I have seen been adequately answered) that during the process of mutation, many of the variations would not only be of no higher advantage to the creature producing them, but would be a positive disadvantage. I can only instance—that birds with wings in a rudimentary state would be only impediments, and result in their destruction, in which case birds

that could fly in the firmament of heaven would never have been evolved. Or, if we suppose the mouse to have been the progenitor of the bat, the elongation of the fingers during the slow progress of the formation of the membrane could only have incommoded it. There are other cases which present grave difficulties to accepting this theory, Take the case of double evolution that would be required, (and remember, not by design, but by accidental variation) in the case of orchids which require for their fertilisation the assistance of particular insects. In this case the variations of the plants and animals must have been coincident in time and area.

How could the eye be formed by accidental variations without respect to the law of optics, the heart without respect to the laws of hydrostatics, so with the ear and various other organs? But the original monad had none of these organs, not even nerves to become sensitive (which Darwin takes as the basis of his supposition.) Admitting this difficulty, he affirms that into some 8 or 10 primordial forms, the Creator breathed the breath of life. But if 8 or 10 be admissible, why not 100, why not 1000? The answer is hard to give.

Again, in regard to special powers, as in the cell making bee. How is it that if this be the result of some most wonderful power of Natural Selection, there are some 250 kinds of bees, (not extinct) but all working alongside each other, which do not make hexagonal cells, and some of which are necessary to the continuance of plants, as in the case of the humble bee, which is necessary to the fertilization of the red clover.

And when we come to man—by what principal of Natural Selection and struggle for existence, can we explain mental and moral qualities that distinguish him from the brute creation. How account for the faculty of speech, which, as Max Muller says, is the great barrier between the brute and man. "No power of Natural Selection can ever distil significant words out of the notes of birds or the cries of beasts."

All these points, as I said, I have been obliged simply to notice. But, lastly, nothing that has been said has accounted for the "*origin* of species." That is as far in the dark on

this theory as ever, and we are compelled to seek for other sources for explanation of it. Trace back, if you can, by the surest steps, the long drawn series which, culminating in man, goes back through thousands upon thousands of varied forms to the very lowest form in which life, not only is known, but can be supposed to have existed, and still, upon this theory, its *origin* remains unknown.

Let us now consider in Mr Darwin's own words the conclusion which he places before us.

"Therefore, on the principle of Natural Selection with divergence of character, *it does not seem incredible* that from some such low and intermediate form as the spores of Algæ both animals and plants may have been developed; *and if we admit this*, we must admit that all organised beings which have ever lived upon earth *may have descended* from some one primordial form."

Now if we had met with this in a work on logic, to show how that art might be used in illustration of what is usually called "begging the question," we should not have been startled; but to find it seriously used in a scientific work for the purpose of supporting a theory, certainly does startle us. If we admit that which has to be proved, of course difficulties vanish. But, if we admit that every individual being starts from a common origin, the same germinal vesicle, we want still to know the origin of that. The spore of the seaweed came from a seaweed, but where did the seaweed come from? Go back as far as you can, Creation must come in at last, and a Creator and Designer. And the religious element, as it is called, really does not come in more powerfully in favour of successive creations of species, than if we believe in an original Creation, having the design by an overruling Providence, to "evolve" successive species from the "primordial form." The one appears to me as grand an exhibition of power, and wisdom, and forethought in the Creator as the other; but, until we have better evidence than Mr. Darwin has brought, that such has been the course of God's providence I, for one, shall decline to hold more loosely the theory of suc-

cessive creations, which has been sufficient to account to the minds of thinkers, certainly as capable and as logical as Mr. Darwin, for all the known facts in relation to the organic world.

Mr. Darwin himself admits " that a difficulty has been advanced, that looking on the dawn of life, when all organic beings, as we may imagine, presented the simplest structure, how could the first steps in advancement, or in the differentiation and specialisation of parts have arisen? I *can make no sufficient answer*." he says; " and can only say that as we have *no facts to guide us*, all speculation on the subject would be baseless and useless." And yet he wishes us to believe, after admissions like this, that not only are such things possible, but that they did take place; and asserts that hereafter we must ignore former opinions on the subject, and accept his theory as the only rational explanation of the facts of nature.

The most that Mr. Darwin has done is to show that naturalists may have pushed their differences between varieties and species too far; but that species exist, by whatever term we may choose to call them, is clear. I have instanced to you the necessity of caution in the reception of facts, until those facts have been established by the test of wide experience and observation. I have further warned you against the acceptance of causes, principles, or laws which do not cover the whole ground of the facts they are to explain; and, above all, against the acceptance of hypothetical theories, based upon an abuse of the imagination, and supported by baseless suppositions and inconclusive reasoning.

However we may accept any theory of the formation and causation of matter, we must ultimately come to a point where science has to confess itself powerless to go further, and where the only solution is that of revelation, a Creator, and Universal Orderer. To what end were things created and led up to man, if not created by God who had the good of His creatures as the end? The laws of science must themselves be limited, as it is contrary to reason to assume a law without a lawgiver, a rule without a ruler. The highest conception the human

mind can form of greatness and wisdom is that in which order prevails by the direction of the orderer, and not that in which a Creator leaves his creation to the conditions of chance. But to suppose that the Creator of law cannot control the action of one law by the operation of another is to limit His omnipotence. The fact of the power of the *human will* to divert the chain of causation ought alone to be sufficient to disprove such a necessity. If human will can prevent the consequences of certain actions by its power, how much more may a power which is unknown in its potency as the Creator's, prevent the action of one law by the interposition of another. And when we consider the so-called " self-evolving powers of Nature," we are constrained to ask—What is Nature but another name for the Unknown, unless we believe in a Creator?

How are we to account for the origin of matter? how for the appearance of vitality? Much more, how are we to account for its continuance in Species without reference to the ordinance and controlling government of a Creator who, in His wisdom, has established boundaries beyond which the imagination may, but beyond which the stern realities of fact cannot pass. All experience goes to show that there are limits which cannot be overstepped, and to assume from probability that which experience belies, is a forced and unnatural method of proceeding, unworthy of a scientific mind.

LIVERPOOL GEOLOGICAL ASSOCIATION.

January 8th, 1883.

At the Ordinary Meeting, held this date, at the Free Library, Mr. Henry Bramall, M. Inst., C.E., President, in the Chair, the following were elected Members:—Messrs. H. C. Bannister and W. H. Davies, Jun.

Proposed as Members:—Messrs. Frederick G. Clark, 47, Bickerton Street, Lark Lane; Henry Hall, H.M. Inspector of Mines, Rainhill; James E. A. Rogers, 7, Oak Terrace, Beech Street, Fairfield; William Hewitt, 21, Verulam Street; and H. F. Tildsley, 121, Queen's Road, Liverpool.

LIBRARY.

The President announced that the Council had arranged for the Library to be opened to Members, and had appointed Mr. Anthony W. Auden as Librarian.

DONATIONS.

Ramsay's "Geological Survey Memoir of North Wales," *presented by Mr. Henry Bramall;* Murby's Text Books, "Geology" and "Botany;" sundry Botanical and other Diagrams, *presented by Mr. F. P. Marrat.*

COMMUNICATION.

Mr. Isaac E. George drew attention to a Paper by Prof. Bonney in the Quart. Journ. Geol Soc. on some structures in Volcanic Rocks from North Wales, and exhibited specimens and rock-sections from the localities mentioned.

Abstract of the

DISCUSSION

On the Paper by Mr. Hugh F. Hall, F.G.S., read on December 4th, 1882, entitled

"SOME OBSERVATIONS ON THE DARWINIAN THEORY OF EVOLUTION OF SPECIES."

Mr. Thomas Brennan, in opening the discussion, remarked that, as Mr. Hall's Paper was still in the hands of the printer, many points which deserved careful attention would probably have been omitted from the notes which he had taken at the meeting. He divided the Paper into three parts.

1st. Criticisms more applicable to the book than to the theory under consideration. 2nd. Facts which, according to the author, are opposed to the Evolution theory. It will be necessary to examine these latter at some length. 3rd. Theological arguments, which for many reasons, cannot well be discussed in a Scientific Society,

The criticisms may be summed up as follows:—A clear and precise definition of the term *species* is of the utmost importance in any discussion concerning their origin. Mr. Daıwin has not given a definition; he says, on the contrary, that the term is undefinable, and, lastly, he has not given us the *origin of species* at all.

Surely when an author writes about something which he shows is indefinable, it is rather unreasonable to complain that he has not given us a definition. Our author, who the speaker supposed, believes species to be definable, is quite as remiss on the point as Mr. Darwin. Of course he admits that there are good and true species, but the only true test given us is that the offspring of distinct species are infertile. It is at once seen that this test is of no practical value outside the domain of our domestic animals and cultivated plants. Of its theoretical value he would speak presently. That Mr. Darwin does not give the precise origin of any species is a fact no more opposed to his theory than the omission to explain the origin of the solar system is adverse to the acceptance of Newton's discoveries; or that our inability to name the Teutonic ancestor of each English family inclines us to discredit the general belief in the Anglo-Saxon origin of a great part of our nation. The sterility of hybrids and the fertility of mongrels are the strongest arguments used by our author. It is here that the want of a clear definition of species is of importance, as when we point to the sterility of closely allied varieties, our opponents claim them as distinct species, and when we point to the fertility of distinct species, they claim that they were only varieties. So it will ever be. If it be a mark of distinct species that the offspring are infertile, hybrids will always be infertile. There is, however, another

way in which we can try the validity of this test. There are two seaweeds, which we may denote as No. 1 and No. 2. If we fertilize No. 2 with the male element of No. 1, they are perfectly fertile, but if we cross No. 1 with the male element of No. 2, they are as perfectly sterile. By the only test which our author gives us, these are varieties and distinct species at the same time; or, in other words, this one species is two and these two are one. This test, then, like all others which have been attempted, fails to define this shadowy abstraction called "species."

Another difficulty brought forward by our author is that animals which become feral revert to the original type. There are very few cases in which we can say what was the original type. In the case of feral horse there should have been two original types, as those in America differ from those in Asia. Reversion is nevertheless an established fact, but followed out it proves too much for our opponents; horses are sometimes born with the "cross on the back" like the ass, and with stripes on the body and legs like the zebra and quagga, their parents being devoid of such markings. These we believe to be reversions to the original type which gave birth to the four species of *equus*.

The difficulty about double variations and rudimentary organs will vanish if our author will shake himself clear of the notion that species spring into existence exactly as we see them now. If he can carry his mind back to a time when the bird itself was in a rudimentary state, when the flower and the insect were less dependent upon each other than they are now, it will be easy for him to conceive that each would be as well fitted for the circumstances in which it lived as it is now.

Persistent types are not by any means unfavourable to the Evolution theory; there is no more reason why the original form should not live side by side with its modified descendants than there is that the London and North Western Railway Company should not have a line from here to London because they have branch lines to Bristol and Nottingham. The

lingula has existed from the Cambrian to the present time, the same fungus which lived on the Silurian corals is found fattening on the deep sea corals of the present day, showing that the law of continuity is as applicable to the organic world, as it is admitted to be to the inorganic; so far, therefore, they contradict the theory championed by our author. All theories have their difficulties, which, with our present knowledge we are unable to explain; Evolution is no exception to this rule, but we repudiate the idea that, because we are unable to explain them, they are incapable of explanation.

Our author, unless the speaker had misunderstood him, asserts that there are no facts in favour of the theory of Evolution. He did not wonder in that case at the author's surprise that scientific men have so universally accepted it. It was his duty, as leader of the discussion, to recall a few facts.

The speaker would appeal first to our own science, and he who runs may read the following facts in it. The great classes into which animals are divided make their appearance on the earth in the order in which they would do if the evolution theory were true; that is, the simplest organisms appear before the more complex ones; the lower orders of each class come in before the higher. As the animals become more complex the variations go on more and more rapidly, because an organism with twenty variable parts will present opportunities for favourable varieties more numerously than one with only two such parts. Lastly, they become more and more like the animals now living, as we approach nearer to our own times.

We find nothing higher than the invertebrata throughout the vast thickness of the Laurentian, Cambrian and the greater part of the Silurian system. In these we find that the brachiopods precede the lamellibranchs, the tetrabranchiate cephalopods come in before the higher dibranchiate. The fishes of the Lower Ludlow beds are of a high order; but Pandar has found some objects in the Lower Silurians of Russia which he believes to be the teeth of fishes allied to the Lampreys. More recent discoveries in the Carboniferous

rocks of Canada have strengthened Pandar's determination of these conodonts; so the generalization holds good that the lower order precedes the higher. It is not till we reach the Carboniferous period that we find the amphibians, which are succeeded by true reptiles in the Permian rocks. The Permian period has been called an appendix to the Carboniferous, and we cannot but notice that the difference between the amphibians and the reptiles is very slight. In the Trias we meet with mammals for the first time, and, true to our generalization, they are of the marsupial order. Birds probably existed during the same period, but we have no positive proof of the fact. Marsupials continued throughout the Oolitic period, but no trace of them is found during the Cretaceous or the period represented by the great unconformity between the Cretaceous and the Eocene. This great gap in the history of the mammalia is but one out of many proofs of the imperfection of the geological record. During this period the marsupial mammals would, according to our theory, undergo rapid variations and specialization, and instead of wondering, as geologists did, twenty years ago, at the sudden appearance of such a varied fauna as the London and Paris basins reveal to us, we hold that it is just what we should expect when conditions favourable to the preservation of fossils occurred after such an interruption as that just pointed out.

The power of prediction which a theory gives is justly looked upon as the strongest proof that can be given of its truth, and it is to what may be termed the fulfilled predictions found in Mr. Darwin's book, that the almost universal acceptance of his theory may be attributed. To account for the wide difference between animals, Mr. Darwin was obliged to plead that the intermediate forms were lost, and he was met by the taunt that it was very easy to prove any theory by such pleading. I imagine that it is too late now to take up such a position, as the intermediate forms are no longer conjectural, but as much a part of our zoological chain as any living form. As if Mr. Darwin had the gift of prophecy, he singled out the birds as widely removed from the other classes of verte-

brata. Three years after the publication of "The Origin of Species," the archæopteryx was discovered, its long jointed tail allying it to the reptiles, while in other respects it was a true bird. Another specimen showed that it possessed reptilian teeth, thereby fulfilling another prophecy made respecting this particular form. Soon after Huxley showed that the Dinosaurian reptiles, despite their huge size, were very bird-like in their structure. A few years afterwards Messrs. Marsh, Cope, Leidy, and others described a number of toothed birds from the Cretaceous beds of America.

The Hesperornis had teeth set in a groove, rudimentary wings, and a tail consisting of twelve joints, while the Ichthyornis had the teeth implanted in sockets, and the joints of the backbone were bi-concave, like those of a fish. Living with these reptile-like birds were a number of bird-like reptiles; the Pterodactyles and Pteranodons, which Professor Seeley believes should be classed with the birds.

In the Tertiary beds of America we have a wonderful series of horses, besides many other less perfect series, connecting animals now living with their Eocene predecessors. Even in our own Eocene beds Professor Owen, not then a friend of the Evolution theory, calls attention to animals belonging to one order having some of the characters of what are now distinct orders. We have in the American bed the Diceratherium, connecting the Perissodactyle (odd toed) ungulates with the Antiodactyle (even toed) ones, the Dinocerata uniting the ungulates and the proboscedians, and the Tillodontia combining the Carnivora, Ungulata, and Rodentia. Such facts might be multiplied tenfold, thus reducing the number of the "missing links."

While palæontology has thus been busy breaking down the barriers between the different classes and orders, embryology, morphology, and the kindred sciences have been adding fresh links in the chain of proofs establishing the truth of the theory of Evolution. Embryology shows us evolution going on under our eyes, all animals beginning alike as a simple cell, gradually evolving the complex structures which cha-

racterise the future animal. The same elements produce in one case the fin of a fish, in another the wing of a bird, in another the paddle of a whale, in another the fore-limb of a quadruped, and in another the arm of a man. Professor Parker affirms that at a certain stage of their development the skull of a parrot and that of a crocodile are so much alike that the same diagram would serve to illustrate both.

The splint bones representing atrophied toes in the horse, and the three toes found in the allied genera rhinoceros and tapir, the upper incisor teeth found in the foetal calf, but not in the cow, and the teeth found in the foetal whalebone whale, when viewed with the occurrence of teeth in allied species, point to a common ancestor in each case, even if we were unable to connect these animals with the fossil whales and ruminants which possessed these teeth throughout life. The old theory can give us no explanation of the facts collected from so many different sources; so far from explaining them, it gives up the atttempt in despair as beyond the knowledge of man. Special creation bears the same relation to evolution that ancient astronomy, with its cycles and epicycles, bore to the generalizations of Sir Isaac Newton. The cycles and epicycles required continual readjustment, as the life of the earth, according to the old theory, required readjustment at every page of its stony history. Newton's discoveries brought the solar system within the scope of general laws, as evolution brings the organic world within the scope of the law of continuity. The present organized beings are, in our opinion, as truly the offspring of the extinct forms as the present physical features of the earth are the results of past phy-features. Continuity being conceded in the inorganic world, continuity in the organic followed as a necessary consequence or to quote Professor Huxley, "Darwin was the natural successor of Hutton and Lyell, and the Origin of Species was the natural sequence to the 'Principles of Geology.'"

Mr. I. E. George expressed his regret that the author of the Paper under discussion had not enlarged more fully on the geological facts bearing upon the subject. The author

had also failed to explain in what manner, in the absence of the Evolution theory, the different facts connected with the geographical and geological distribution of animals and plants were to be interpreted. The speaker pointed out that a study of fossil forms of life afforded some of the strongest arguments in favour of Evolution. Some animals which became extinct with the post-pliocene period have been frequently followed by closely allied forms now living in the same districts. South America, for instance, has furnished us with fossil mammals allied to the sloths and armadillos, but of different species to those now inhabiting that Continent. In Australia, also, extinct species of kangaroos have been discovered in the post-pliocene rocks. Referring to the author's argument that some of the earliest known fossil fishes in the old red sandstone are of a high order, and that there was little evidence of lower orders of fishes having existed, the speaker thought that it offered no proof against the theory of Evolution. The ganoid types of fishes were protected by a thick coat of armour, which would aid their preservation, and he considered that of the various groups of fishes which existed in those early times, only the ganoids possessed skeletons of sufficient toughness to be handed down to us uninjured.

Mr. F. P. Marrat pointed out that the brachiopods are closely related to the syphunculoid worms. They might, perhaps, be a connecting link between molluscs and worms.

LIVERPOOL GEOLOGICAL ASSOCIATION.

February 5th, 1883.

At the Ordinary Meeting, held this date, at the Free Library, Mr. HENRY BRAMALL, M. Inst. C.E., President, in the Chair, the following were elected Members:—

Messrs. Frederick G. Clark; Henry Hall, H.M. Inspector of Mines; James E. A. Rogers, William Hewitt, B.Sc., and H. F. Tildsley.

Proposed as Members:—Messrs. David Davies Pritchard, 10, Lothair Road, Anfield; Philip Owens, 66, Orient Street, Everton; H. E. Brown, 25, Bank Road, Bootle; and William Wright, 41, Langham Street, Walton.

DONATIONS.

"The Formation of Vegetable Mould through the action of Worms;" by Chas. Darwin,—*Presented by Mrs. H. P. Shilston*; "Annual Report, 1882, of the Liverpool Amateur Photographic Association,—*Presented by the Association*; "Abstract of Proceedings Liverpool Astronomical Society,—*Presented by the Society.*

The following Paper was read,—

"THE CONTORTED BUNTER SANDSTONES OF WIRRAL."

BY ISAAC E. GEORGE.

The Cheshire Peninsula has long been known to geologists as containing at least one member of the Triassic period in which footprints of the long-extinct Labyrinthodont have been favourably preserved. Beyond these, and other kindred

impressions occasionally met with, the geological collector finds little in the red sandstone to divert his attention from the adjacent carboniferous rocks, which always hold out better hopes of fossils. Probably it is on this account that many interesting features in connection with our local red rocks have not received the attention which they merited; so that many problems bearing on the structural geology of the Trias which might otherwise have been worked out have scarcely suggested themselves. The present Paper is an attempt to give some account of the facts bearing upon one of these problems, with an explanation of the probable mode of origin of the structures to which it has reference.

Under the guidance of Mr. Thomas Brennan, members of the Association have recently had an opportunity of examining a section at Wallasey in which the contorted structure is strikingly developed.* Other sections, much the same in general appearance, exist at Bidston and Thurstaston. The Sandstones in which they occur are always well jointed, and frequently traversed by *faults*. In this respect they resemble all those rocks which are the result of the consolidation of sheets of sediment, and which have been afterwards dislocated by the action of internal forces. Both of these structures have been closely studied; and their phenomena, as developed in the Bunter Sandstones, are readily separable from those associated with the contortions. But their frequent existence side by side with the latter is noteworthy, and may help us to draw an important inference when we come to consider the relative age of the contortions. There is still another appearance in connection with our local Sandstones, with which every visitor to Storeton Quarry is familiar. I refer to the iron-stains seen on exposed faces of the rock. More than one section shewing contortions has been passed by without examination, under the impression that the appearances were merely due to iron-stains; whereas the observation should have been followed by an appeal to the pocket magnifying-glass. Examined in this way the Wallasey Section re-

* *Vide* "Transactions," Vol. II., page 84.

veals thin layers of Sandstone, at first nearly horizontal, suddenly flung back upon each other, and helping to form great curves. In the Thurstaston and Wallasey Sections, again, not only are the layers seen to have assumed a vertical position at some points, but they further shew a minute system of dislocations. The alternation of bands of large well-rounded grains of sand with bands of finer material has frequently resulted in the more rapid weathering of the former; so that little ridges of Sandstone protrude, and offer a lodgment to atmospheric dust and vegetable mould. Surface markings of this character, added to the chisel-marks of the road-maker, cause considerable difficulty to be experienced in examining the artificial sections revealed at Wallasey and Bidston.

It appears, then, from the foregoing, that there is something more than a superficial appearance to account for. We must strive to explain why certain bands of Sandstone forming part of the Bunter series should appear as if, on a small scale, they had been violently contorted and dislocated. That the material was not accumulated in this form is evident when the reversed folds, the minute puckerings, and the dislocations are considered.

In commencing the enquiry it is possible to reduce the question to a comparatively narrow limit by deciding when the contortions occurred. At what period in the history of the Sandstones were these structural characters impressed upon them? was it while the layers of sand were being accumulated on the floor of the Triassic sea? or was it at a later period when the thick masses of Bunter Sandstone were undergoing consolidation? If not at either of these periods then it must have been subsequent to consolidation. So far as the sections now under consideration are concerned there is evidence to shew that the events occurred in neither of the two stages last mentioned. The joints, which mark the time of consolidation, are seen traversing the rocks as straight lines even when cutting across the areas where contortion is most marked. Any appeal to those *internal forces* which are

the acknowledged source of contortions affecting rocks on a large scale is out of the question here, as the bands affected are seen to be overlaid by others shewing no signs of contortion.

The evidence seems, then, to point to a contemporaneous origin. The sandy layers must have been contorted as they formed the floor of the Triassic sea, and before they were covered up by the sheets now resting upon them.

The agencies hitherto recognised as capable of producing contemporaneous contortions are not numerous. Drifting masses of ice, which have been a fruitful source of disturbance in Post Tertiary Sands, will not avail us in the present case. None of the Bunter contortions are associated with a shelving beach on which such masses could have been stranded. Nor do I know of any instance in which ice-borne fragments of rock, the almost inevitable accompaniment of floating bergs, have been found included in the Wirral Sandstones. On the Southern and Eastern coasts of England, in the present age, contortions must frequently be produced where tracts of land slide bodily into the sea. But there is no reason to suspect that any elevated land masses existed in the immediate neighbourhood of any of the sections now under consideration.

Let us examine more particularly the surroundings of our sections. It will be seen that denudation in one case, and denudation combined with faulting in the other, have removed some of the strata which were originally continuous with, or resting upon, the contorted sheets at Thurstaston and Bidston; so that in these two sections we are left without much information that might have been found useful in the present enquiry. The following points may, however, be noticed as occurring at Thurstaston in the section exposed on the Southern face of the rugged outlier known as "Thor's Stone." In the South-Eastern corner laminæ having a vertical arrangement are suddenly cut short above, and overlaid by laminæ of Sandstone having at first a normal arrangement, but becoming contorted higher up. In the upper portion of the Stone generally, the

laminæ shew current bedding. A singular appearance is noticeable in the South-Western corner. Current bedded laminæ, rising gently to the East, are seen to have been violently flung back upon themselves, a minute system of dislocations being developed at the same time. To the right of this highly disturbed area the lamination is undistinguishable, and the arrangement may be described as being chaotic. In the cutting at Bidston, too, there is present a system of curves and flexures, accompanied by minute puckerings and slight dislocation, the uppermost part of the section showing a normal bedding. The section exposed by the roadside in Wallasey Village is more complete than either of the others. Both to the left and right of the contorted bands current-bedding is developed at a smarter angle than usual; while the whole series is overlaid by sheets which are nearly horizontal. To the right the contortions have not died away at the point where contemporary denudation has stripped away a part of the original floor, but the section is more complete on the opposite side of the disturbed area.

And now as to the origin of these strange appearances. Professor Geikie, who has treated of this matter in his recently-published "Text Book of Geology," states (p. 479) that "curved and contorted lamination is of frequent occurrence among Palæozoic Sandstones," but adds that "the cause of this structure is not well understood." One of the illustrations given by him is taken from the Cambrian Sandstones of Gairloch. It will be seen that in the Wallasey and Thurstaston sections current bedding is constantly associated with contortion. An enquiry into the conditions under which current-bedding was developed and contemporary denudation carried on at the time when the Bunter Sandstones of Wirral were being accumulated, may help to explain the contorted structure; the probability being that the same forces which produced the former appearances, were indirectly the cause of the latter.

The New Red Sandstone of England is regarded as having been laid down in a large inland sea, or series of lakes.

Into these basins, large rivers would discharge their loads of gravel, sand and clay. The disposition of this sediment on the floor of an inland sea would be far different from that found to prevail where rivers similarly charged have entered oceanic basins. In the latter case there is usually a powerful current, either tidal or oceanic, sweeping past the estuary or delta, so that the river frequently maintains itself as a stream, far out into the sea. In this way a complete arrangement of materials according to weight would tend to follow; coarse gravel and sand being the first to settle down, while the finer sand and mud would cover extensive tracts of the sea-bottom, at a greater distance from land. In an inland sea, on the other hand, rivers would have their velocity checked very speedily, so that a greater portion of the sediment would be deposited close to the shore. The rivers, too, would split up into an indefinite number of currents, each traversing the waters of the sea for a short distance, with a rapidly decreasing speed. From extended observations of the disposition of the sediment composing the Bunter series of Wirral, I am inclined to think that, in one respect, material suspended in these currents was afterwards deposited in a manner similar to that found prevailing at the mouth of the Mississippi to-day. Here the submarine channels are so continuously built up by deposition of sediment on their banks and floors that they at last begin to appear above the surface of the water. The "dip" of the *oblique lamination* developed under such circumstances would be directed towards the centre of the channel. In the New Red Sandstone channels have been built up in a similar manner, as shewn in the Middle Eye section. (See figure.) There are also constant indications of branchings or deviations from old courses. Denudation of sediment already laid down would be the result of such movements. Yet, even this will not explain all the phenomena connected with current-bedding as developed in the New Red. I think we require to apply Professor Ramsay's well-known diagram illustrating the behaviour of *winding rivers* to the water-

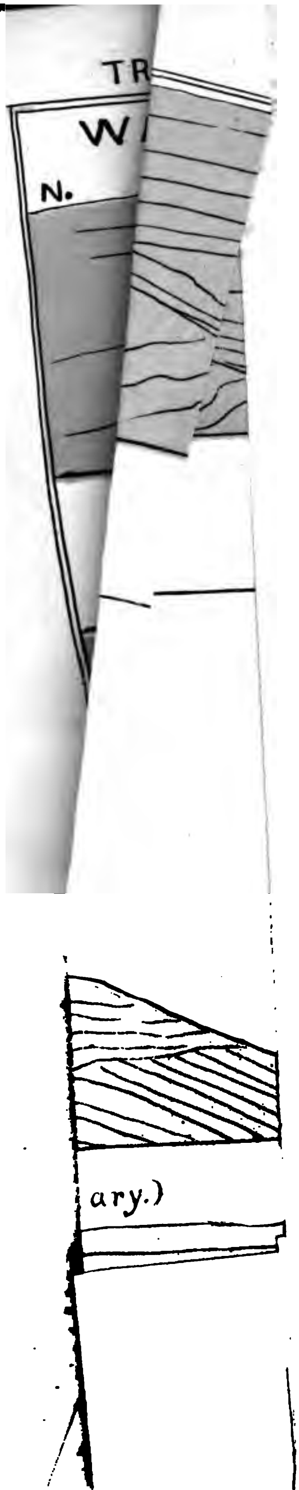
courses of the Triassic Sea. The Middle Eye section shews this very well. A band of hard conglomeratic sandstone, resting on the red conglomerate which forms the base of the cliff at this point, was partially denuded from the South. Erosion appears to have taken place rapidly on the Northern bank of the channel, whilst oblique laminæ were being deposited on the more sheltered Southern bank. This was probably of far greater height than the present upward termination of the laminæ and possessed considerable steepness. Higher up in the section are to be seen the layers accumulated on the shelving bank of another channel. The superior thickness of this bed shews that it escaped denudation to a greater degree than the lower ones.

Having now recognised the existence of powerful denuding currents and steep sandbanks in the Triassic Sea, we may refer again to the Wallasey section shewing contortion. At the Southern end we note that disturbed sheets are brought to an abrupt termination at the edge of what was once a tall sandbank. Upon this steep slope oblique layers of sand were afterwards laid down. Northwards, a great thickness of material, in section not deviating very much from the horizontal, is brought to an abrupt ending in much the same manner. A long sandbank, facing South, marks the Northern limits of a denuded area. On the steep side of this bank the current afterwards laid down sheets of sand having a somewhat perilous slope towards the channel. May it not be that in the instability resulting from such conditions of accumulation we have a key to the origin of the contortions close by. The upper portions of a steep bank, in gravitating to a lower level, would most probably do so at the expense of the sheets then forming the floor of the channel. Subjected to great lateral pressure, these would be thrown into a series of curves and folds, and might possibly be faulted where the pressure was unusually severe or too suddenly applied.

It is to be remarked that the Northernmost beds in the

Wallasey section shew a slight stooping as they approach the margin of the sandbank. This result would follow if a downward movement had taken place here. It is to be regretted that the section is incomplete. The foundation of the contorted tract is not visible, and the upper ranges of the curves had been denuded before the superior strata were laid down. The Bidston and Thurstaston sections are still more incomplete.

The hypothesis now laid before you, formed, as it has been, by the study of such fragmentary material, is necessarily tentative, and requires confirmation when other sections more favorably preserved shall have been critically examined. Such sections are no doubt in existence, and it is to be hoped that attention will speedily be directed to them. Meanwhile, we may feel assured that the last problem in connection with the New Red Sandstone has not yet arisen, and that for many years to come we shall continue to find matter for discussion in the formation on which, as Liverpool geologists, we must needs continue to bestow the greatest share of attention.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LIVERPOOL GEOLOGICAL ASSOCIATION.

March 5th, 1883.

At the Ordinary Meeting, held this date, at the Free Library, Mr. HENRY BRAMALL, M. Inst. C.E., President, in the Chair, the following were elected Members :—

Messrs. D. D. Pritchard, Philip Owens, H. E. Brown, and Wm. Wright.

Proposed as a Member :—

Mr. Isaac Roberts, F.G.S., F.R.A.S., Kennessee, Maghull, Lancashire.

DONATIONS.

Annual Report, 1882, of the Liverpool Law Students' Association; Transactions (Vol. II., Part 2) of the Edinburgh Geological Society; Ditto, Parts 3 and 4, Vol. XVII., Manchester Geological Society; Proceedings (Part 4, Vol IV.) Liverpool Geological Society; Ditto, No. 2, Liverpool Astronomical Society: *from the respective societies*;—"The Geological Record," edited by W. Whitaker, B.A., 5 vols., 1874-78, *purchased by subscription*; Croll's "Climate and Time," *presented by Mr. Wm. Owen*; Lyell's "Travels in North America," *presented by Mr. Anthony W. Auden*; "Guide to the Geology of London," by W. Whitaker, B.A., *presented by the author*; Woodward's "Geology of England and Wales," *presented by the Secretary*.

COMMUNICATION.

Mr. FREDERICK P. MARRAT gave a brief Note on "Vermes," (Class—*Annelida*;) and referred also to the tracks made by hidden shells.

Mr. P. B. DEUCHAR then took the Chair, vacated by the President, and a Paper, of which the following is an abstract, was read on—

"THE MINERAL RESOURCES OF NEW ZEALAND."

By Henry Bramall, M. Inst. C.E.

PART I.

The dwellers in a great seaport like Liverpool cannot but feel a deep interest in those distant Colonies, where our fellow countrymen are making for themselves new homes, conquering the wilderness and making it to "blossom like the rose," spreading civilisation, establishing commerce, building cities, founding Empires. And to none of our Colonies does greater interest attach than to that youngest and fairest of them all, which a recent writer has so happily termed "Brighter Britain." The author feels that no apology is needed when he asks your attention this evening to a few notes on the Mineral Resources of New Zealand.

Discovery.—The discovery of New Zealand is commonly ascribed to Tasman, who sighted it in 1642 from his ships but did not land. The honor more properly belongs to our own distinguished Captain Cook who, in 1769, in the Endeavour, discovered the North Island, and afterwards in 1770 formally took possession in the name of George III. at Queen Charlotte's Sound.

Settlement.—No attempt at settlement was made till a mission station was founded at Bay of Islands in 1814; and the sailors and others interested in the whale fishery of the Southern seas made this a resort. Not till 1839 did the British Government proclaim New Zealand as a part of the Colony of New South Wales, and Captain Hobson was sent in 1840 to take possession as Lieutenant Governor. Landing at the Bay of Islands he hoisted the British Flag, and concluded the treaty of Waitangi with the natives. In the following year he was appointed Governor, and New Zealand became a separate Colony of the British Empire. Auckland was founded by Governor Hobson in 1840, Wellington by the New Zealand Company in the same year, New Plymouth and Nelson in 1841. The Scottish Free Church Settlement of Otago dates back no further than 1848, and not until 1850 was the Church of Eng-

land Settlement of Canterbury founded, and yet, in the few years which have since elapsed, the country has been opened up and largely brought under cultivation, handsome towns and cities built, roads and Railways made, Churches, Schools, and Hospitals erected, mines opened and worked, commerce established, and there is now an energetic, wealthy, and thriving community of half a million souls, with an import and export trade of upwards of thirteen and a half million pounds per annum, where, as it were but yesterday, there existed only a savage wilderness over which roamed a handful of still more savage cannibals.*

Situation and Extent.—New Zealand lies far out in the South Pacific Ocean, 1200 miles from the nearest point of Australia, and about 12,000 from England. There are two principal Islands, the North and the South, separated by Cook's Strait. The total area is about 99,000 square miles.

Physical Features.—The country may be termed mountainous, the West and North of the South Island being occupied by ranges of rugged and lofty peaks, towering to heights of

*The population of New Zealand at each decade was:—
1851.............. 26,707, exclusive of Aborigines,
1861.............. 99,022 ,, ,,
1871.............. 256,260 ,, ,,
1881.............. 489,702. Maories, 44,099. Total, 533,801.

The population of the chief cities and towns in 1881 was—Auckland, 16,665, with suburbs 39,966; Wellington, 20,535; Dunedin 24,377, with suburbs 42,802; Christchurch 15,214, with suburbs 30,719.

The value of the trade of the colony is as follows:—

Year	Total Imports.	Total Exports.	Imports of British Produce	Exports to United Kingdom
1878	£8,755,663	£6,015,700	£5,333,170	£4,727,242
1879	£8,374,585	£5,743,126	£5,302,823	£4,171,915
1880	£6,162,011	£6,352,692	£3,479,217	£4,767,068
1881	£7,457,045	£6,060,866	£3,718,308	£5,125,859

The Public Debt on 31st March, 1881, was £29,165,511, or £53 10s. per head of population, including Maories; most of this, however, has been expended on reproductive works, such as Roads, Railways, Bridges, Harbours, &c.

10,000 and 13,000 feet, their summits dazzling in perpetual snow, while down their scarred and furrowed sides descend huge glaciers, some of which on the West Coast reach the low elevation of 700 feet above sea level. The mountains in the North Island are chiefly in the Southern and Eastern parts and are neither so lofty nor so grand as the Southern Alps few attaining a height of 6,000 feet, and only the isolated extinct volcanic cones of Ruapehu and Mount Egmont rising above the snow line. It is stated one tenth of the surface of the North, and four-fifths of that of the South Island are covered by mountains, those in the South Island being on their Eastern Slopes mostly open, well grassed, and adapted for pastoral purposes, while their Western Slopes are usually heavily timbered. At the Eastern foot of the mountains of the South Island, and on the West of those of the North Island, are extensive plains, some of which are of great fertility. The Rivers are numerous, with much of the character of mountain streams, being rapid and only in few instances are they navigable; but considerable improvements have already been made by the clearing away of boulders, snags, and other impediments, and the erection of training walls, and no doubt as years roll on, the indomitable energy and perseverance of the Colonists, will convert many, at present almost unused brawling streams, into busy though silent, highways of commerce.

Geology.—The limited time at our disposal will not permit more than a rapid and cursory glance at the very interesting Geological Structure of New Zealand; and the author can only give such a slight outline of these features as will enable him to be more easily understood when treating of the more immediate subject of this paper.*

The fundamental rocks are the crystalline schists, foliated and contorted gneiss, occurring in the South-West of Otago.

* For most of the facts and information in the succeeding pages the Author is indebted to the official publications of the New Zealand Government, and more especially to those of the Director of the Geological Survey Department—the learned and indefatigable Dr. James Hector, F.R.S., and his able staff of assistants.

They constitute huge mountains, intersected by deep ravines, the sides precipitous, often almost perpendicular. On the West these ravines are occupied by arms of the sea corresponding to the Fiords of Norway, and, like them, they are often of great depth and deeper at the head than at the entrance. Similarly the ravines on the East hold fresh water lakes of great depth, the bottoms being usually much below sea level. True granites—grey, white, and flesh color,—syenites and diorites are associated with these rocks. These are succeeded by an immense series of metamorphosed foliated schists, which cover the larger part (probably more than 8,000 square miles) of Otago, and extend along the West coast of the South Island through Westland and Nelson to the neighbourhood of Collingwood. They have not yet been found in the North Island. The lower members of the series are contorted schists, foliated with quartz, and overlying these, in a few localities where they have escaped denudation, are soft, blue, micaceous slates, containing quartz veins in a friable and decomposing condition. Upon these formations are situated all the important alluvial gold fields of the South Island, and it is generally conceded that the gold has been derived from the numerous strings and veins of quartz by which they are traversed. The age of these altered beds has not yet been satisfactorily determined; they are probably Silurian, but some may be older, and, on the other hand, others may be much younger, possibly Carboniferous.

The lowest unaltered rocks yet described are of Silurian age and occur in the North-West of Nelson, consisting of schists and crystalline limestones; while the Devonian is represented by the quartzites and limestone beds of Reefton. Flanking the belt of foliated schists which runs through the South Island is a great mass of slates and limestones, greenstone breccias and sandstones, extending from the Northern part of Otago, through Canterbury, Marlborough, and Nelson; and again from Wellington almost continuously to the East Cape; while detached masses occur at the Coromandel Peninsula, along the coast north of Wangarei, at the North Cape,

and several other localities. Pitched at high angles, these rocks constitute the chief mountain ranges of both islands, rising to great elevations, in Mount Cook even to 13,200 feet, their tops bold, rugged, and serrated. These beds are probably of Lower Carboniferous age and are of great interest from their frequently holding important mineral deposits.

Passing over the Permian (?) Trias and Lias, all of which are represented, we pause to remark that the Jurassic beds in many places contain small and irregular coal seams, but as yet have yielded none of commercial value.

The Neocomian is probably represented by the sandstones, conglomerates and grits with which are associated the valuable bituminous coal seams of the West Coast.

The formation to which Dr. Hector has applied the name "Cretaceo-Tertiary," from its fossils presenting, to some extent, both Tertiary and Mesozoic features, is widely distributed. In its upper part it consists of marls, sandstones, greensands, limestone, chalk marls and chalk with flints, and is of marine origin. At its base lies the black grit, and, in certain localities, the coal formation in which the principal workable hydrous brown coal seams are found. The fossil plants associated with the coal deposits are ferns and "remains of dicotyledonous and coniferous trees of closely allied species to those represented in the existing flora of the country." (*Dr. Hector.*)

Tertiary beds of Eocene, Miocene, and Pliocene age cover a considerable area in both islands, those of the latter age, containing, in numerous localities, beds of lignite of local importance, and rich deposits of alluvial gold.

It thus appears that nearly the complete Geological sequence of formations known in Europe has already been identified in New Zealand, the gaps remaining to be filled being chiefly in those Archaic rocks found in the mountainous, almost unknown, and scarcely accessible regions of the South-west; these are, at present, but roughly grouped, chiefly from their mineralogical characteristics.

It is noticeable that the general strike of the rocks of the

older formations has a N.E. and S.W. direction, which, as Dana points out, corresponds with the line of elevation in the Pacific Ocean, the same general effect being observed on the East coast of Australia. This line of elevation also corresponds with the general lines of Plutonic and Volcanic outbursts, which extend along the Eastern foot of the mountain ranges of the South Island and the Western foot of those of the North. It is crossed, nearly at right angles, by a line of depression, originating the transverse ruptures to which are due Foveaux and Cook's Straits and the North-east coast line of the North Island. The important part played by volcanic agencies in the formation of the country is seen in the tufaceous breccias and lava flows, which cover so large a part of the surface; fully one-third of the area of the North Island being occupied by these deposits. And that these forces are even now not quite extinct is evidenced by the smouldering cones of Ngarahoe and White Island and the hot springs of the Geyser district; while old Vulcan, by an occasional gentle earthquake, reminds the inhabitants of his near presence.

Mineral Resources.—The mineral resources are rich and varied, and though as yet but imperfectly explored, as we may easily suppose when we remember that the country is as large as Great Britain, and the population less than that of Liverpool; still enough has already been discovered to indicate the future development of immense wealth. In the following notes no attempt will be made to treat systematically of the mineralogy of the country, but those minerals only will be noticed which are of commercial importance.

COAL.

No true palæozoic coal has yet been found in New Zealand, all the seams known are of late Mesozoic or Tertiary age and of the kind usually termed by geologists Brown Coal; yet the varieties of quality range from Lignite, but little removed from Peat, to Coal which in appearance and composition cannot be distinguished from true Anthracite, these variations chiefly resulting from purely local causes, such as the contact or proximity of volcanic dykes or flows, which

have deprived the hydrous coals of more or less of their water. The varieties may be roughly classed as follows :—

Lignite, woody structure; 15 to 30 per cent. water.

Brown Coal, compact structure, 10 to 20 per cent. water.

Pitch Coal, conchoidal fracture, water usually under 10 per cent.

Bituminous or Coking Coal, laminated and cuboidal, water less than 5 per cent.

Anthracite, very dense and compact, practically anhydrous.

The principal coal fields are the following :—

The North Auckland Coal Field extends from South of Wangarei to near the Bay of Islands, a distance of more than 30 miles. The field is bounded on the East by palæozoic slates and sandstones, and in the hollows of these rocks lie the beds of the Cretaceo-Tertiary formation, at the base of which are the coal seams. Near Wangarei Harbour these beds cover an area of about 16 square miles, with two seams of coal, the upper 4½ feet and the lower or main seam 6 feet to 10 feet thick. The coal is pitch coal of good quality and is worked at the Whau-Whau and Kamo Collieries. Northerly from Kamo the surface is chiefly covered by basaltic and trachytic rocks for about 9 miles to Hikurangi, where numerous outcrops of seams have been noted, varying from 2 feet to 6 feet, but none have yet been worked. Further North the country is chiefly slates with tracts of overlying volcanic rocks to Kawa-Kawa, where a basin-like area of coal measures occurs, consisting of a series of green and brown sandstones and limestones, containing two seams of coal, the upper being 4 feet 3 inches thick, of inferior quality. The lower or main seam is from 6 to 15 feet thick Pitch Coal, hard, compact, and of good quality, and is now worked by the Bay of Islands Coal Company. A notable point about this coal is the large amount of sulphur it contains, stated at about 5 per cent., not, as is commonly the case, in the form of pyrites, but the greater part oxidised as free sulphuric acid, which is even said to communicate a sour taste to the coal.

The total area of this basin is estimated at 10 square miles. North from Bay of Islands the country is chiefly volcanic, but at the head of Wangaroa Harbour a seam of Brown Coal is found outcropping among green sandstones. Still more North at Mongonui coal outcrops are known to exist.

Dr. Hector, in 1865, received a specimen of Shale resembling Torbanite from this district, which contained 75 per cent volatile matters, but "no other specimen was found" and although Mr. McKay visited and searched the locality in 1875 he failed to find the deposit. It is needless to remark how valuable a workable bed of this mineral might prove if found in an accessible position.

Coromandel.—Small deposits of Brown coals have been found at several points of this peninsula, and quite recently a bed of excellent bituminous coal is reported from Tiaroa.

South Auckland or Waikato Coal Field.—So far back as 1859, a coal seam about 6 feet thick was opened at Drury, 20 miles south of Auckland, but the coal was inferior, crumbling on exposure and the irregular floor of clay, bad roof and costly freight caused the works to be abandoned after 4 or 5 years and they have since remained closed. The coal basin of the lower Waikato extends from Mercer southwards to Taupiri about 35 miles with a breadth of probably about 20 miles. The basement rocks of the country are palæozoic slates of undetermined age, very pyritous, and much disturbed, and which rise into a range of hills extending from near the Firth of Thames by Taupiri to near Waipa, and form the eastern and southern boundary of the coal basin. Upon their flanks and hollows repose a series of shales and sandstones with coal seams, supposed to be of Lower Greensand age, and these are in turn overlaid by the *Leda* Marls, the lowest beds of the Cretaceo Tertiary formation. The whole suggests the site of an ancient estuarine lagoon. On the East, within 7 or 8 miles of the Thames Gulf, a shaft was sunk at the Bridgewater Colliery, the measures passed through being :—

Leda Marls and Fire Clay	17 feet.
Sandstone	2 ,,
BROWN COAL	55 ,,
Shale	2 ,,

The coal is good, but the venture has not been successful and the colliery is now closed, Near Taupiri Gorge, in the south, at the Taupiri Colliery, the coal is 31 feet thick, divided by a shale band; and at the Kupa-Kupa or Waikato Colliery the seam is from 18 to 23 feet. Both these collieries are working and help to supply Auckland city. It is estimated that not less than 150 million tons of coal are available in this district. At other points on the West and North-West outcrops of coal seams are known, but, partly owing to the objections of the natives, the district has not yet been fully examined. There appears at least strong presumptive evidence that coal will be found to underlie the greater part of the lower Waikato basin.

Mokau.—South of the Waikato field, on the River Mokau, outcrops of seams 2 feet to 6 feet thick, have been examined by Dr. Hector, who reports them to be pitch coal of good quality and probably of lower greensand age. The densely wooded nature of the country, which is in the hands of the natives, prevented the extent of the outcrops from being traced, but these were found at several miles apart.

Wellington.—Brown coal has been found in this province on the Wanganui and Rangitikei Rivers.

The Nelson or West Coast Coal Fields in the South Island are perhaps the most important in the colony. They occur as detached deposits in the hollows of the older rocks and extend from West Wanganui to Grey River about 150 miles. On the older rocks lie the sandstones, shales, and coal seams of lower greensand age, overlaid by the Cretaceo-Tertiaries. At Collingwood there are four seams of excellent bituminous coal, from 3 feet to 4 feet in gross thickness, but so mixed up with shale partings that the working of them has been repeatedly abandoned. At several points in the vicinity good outcrops are known. At West Wanganui inlet a four feet seam has been worked, but unsuccessfully.

The Buller Coal Field extends from the Mokihinui to the Buller, about 40 miles, with a maximum breadth of 7 miles. The country is broken and rough. Rising from the Buller River by a succession of terraces, at an elevation of from

1,500 to 2,500 feet, is a great bare plateau, sloping gently to the north-east, descending to sea level near the Mokihinui. Intersecting this plateau are well timbered, deep, precipitous gorges, on the sides of which are exposed sections of the coal seams. Of these there are two—an upper very irregular one of 1 foot to 5 feet thick, and a lower, the main seam, ranging from 8 feet to 58 feet thick. The quality varies in different parts from a tender, bituminous coking coal to a splint or cannel coal. Several attempts have been made to work this field, but not with very satisfactory results; recently however, the Westport Coal Company has opened a colliery which gives good promise. The quantity of coal available is estimated at one hundred and five million tons. The Buller River is the best port of the West Coast, and is capable of being greatly improved, and as the coal seams on the plateau are thick, compact, and of superior quality, and can be won in most cases by level drives, the difficulties of transport will eventually be overcome, and, with the judicious employment of capital and technical skill, there ought to be a good future before this district.

The Grey Coal Field, about 7 miles above the mouth of the River Grey, extends about 15 miles north and south. There are several seams, the principal one being 12 to 16 feet thick of bituminous coking coal, overlaid by sandstones and having a fireclay seat. This coal is probably the best gas coal in Australasia. There are working here the Brunner, the Coal Pit Heath, and the Wallsend Collieries. Defective transport and a shifting bar at the mouth of the Grey River, which limits vessels to a draft of 9 or 10 feet, are obstacles which have hitherto retarded the development of coal mining in this field, which is estimated to contain about four million tons of available coal.

Reefton is a gold mining town on the Inangahua River, east of Grey, where seams of Pitch coal from 6 feet to 21 feet thick are found and worked on a small scale for local use.

Nelson City.—Some Brown Coal beds found here have led to many unsuccessful attempts to work them; and at

Picton also many trials have been made which have ended in disappointment. Recently a seam has been found at the head of Shakespeare Bay which promises better, and a company has been formed to work it.

Westland.—At Kanieri some coal crops are found which have led to considerable sums being spent in prospecting trials, but no payable seams have been proved.

Further south, from near Paringa River to Moore River, a district extending north to south 25 miles by about 8 miles wide, is occupied by coal measures, and an outcrop of good bituminous coal 12 feet thick has been traced between 3 and 4 miles.

At Jackson's Bay, Cascade Point, and Martin Bay, extensive areas of coal measures are known to exist, but they have not yet been sufficiently examined to justify an opinion as to the value of the seams they contain.

The Malvern Hills Coal Field, about 30 miles west of Christchurch, comprises a district of about 180 square miles. The beds of the great Brown coal formation lie along the east slopes of the hills, and descend towards the plains, beneath which they appear to dip. They consist of sands and shales, with several seams of coal, the thickest of which, however, is only 7½ feet. The district has been extensively disturbed and broken by dykes of trachytic porphyry, and subsequently subjected to enormous denudation in the post pleiocene glacial period. In the western parts, only isolated patches of altered coal remain where basalt cappings have preserved the subjacent beds. The dykes and streams of lava have converted the coal within reach of their influence from Brown to Pitch, or glance coal, and, in some cases, as at Acheron Gorge, to anthracite. There are several collieries working in this field; and the whole available coal is estimated by Dr. Haast at something under five million tons.

At *Clent Hills* and *Mount Somers* are coal seams, but they are of purely local importance.

Oamaru.—Here two seams of Brown coal each 9 feet thick are worked on a small scale.

Shag Point.—The coal measures here flank the Horse Ranges and consist of several thousand feet of conglomerates, sandstones and shales. The uppermost beds of the series extend about 1¼ miles along the coast by about ¼ mile wide and contain valuable coal seams estimated to yield about a million tons, and which are seen outcropping in the precipitous cliffs. The Shag Point Colliery works a seam of pitch coal 7 feet thick, which is followed to the deep under the sea.

Green Island Coal Field, near Dunedin, has an area of about 8 square miles. The measures lie in a hollow of the older slates and have been preserved from denudation by the basalt and dolerite flows which cap the adjoining hills. There are five seams, but only one is worked, varying from 18 feet to 19 feet in thickness, of inferior hydrous brown coal. The roof is bad, so that only 7 to 10 feet of the seam is worked. There are 5 collieries, and the content of the field is computed at 28,000,000 tons.

The Clutha and Tokomairiro Coal Field covers about 40 square miles. The measures consist of conglomerates, sandstones, and clay shales, with several seams of Brown coal, and form a range of hills between the Kaitangata Lake and the sea coast, along which they are seen in section for 3 miles. The seam worked at Kaitangata is from 24 to 30 feet thick, of which from 20 feet to the full thickness is got. The field is estimated to contain one hundred and fifty million tons.

In *Southland* and the south and west of Otago a considerable extent of surface is occupied by beds of the Cretaceo Tertiary and Jurassic formations, and outcrops of coal have been found at many points, but the seams have mostly been too thin for profitable working. At the Nightcaps, Otautau, a seam of Pitch Coal 5½ feet thick is being got on a limited scale, and at Mataura lignite 12½ feet thick has been worked for some years.

Lignite deposits are found in many parts of Southland and Otago. Usually they occur in what are evidently old lake basins, in the surface of the slate rocks in the interior.

They are often of great thickness and owe their origin to driftwood; fragments of trees are common in which the woody tissue is perfect, the most usual being a species of Fagus, the "Birch" of the colonists. These deposits are of quite recent Tertiary age, being usually covered only by brick clays, gravels, silts, or shingle. The lignites not uncommonly contain resinous matter (Retinite) in considerable quantity, when they burn very readily; where this is absent, or only present in very limited quantity, they burn slowly, smouldering like turf, giving off a disagreeable, fœtid odour, and leaving a large quantity of light ash. They are worked at numerons points, usually as opencasts, and on a very limited scale, and where better fuel is scarce and costly they prove very useful for local requirements.

Distribution.—From the preceding notes it will be seen that coal seams are widely distributed through both islands, and no parts except the east of the North, and the north-east of the South Islands are very distant from workable coal. A noteworthy point as compared with British coal fields is the limited vertical depth of measures to which good coal seams are confined; and most of the areas contain only one good workable seam.

Quantity and Duration.—In a new and imperfectly explored country the necessary data for estimating this are very incomplete. It appears that in known areas an available supply of 450 million tons has been ascertained. Any computation of the duration of this supply would in the present state of the colony be little more than a wild guess. The local consumption of coal in 1881 was in Great Britain 3·67 tons, and in New Zealand ·86 tons per head of population. But the increment in population and the development of industries in the two countries are so dissimilar as to preclude our founding any estimate on this basis.

Present State of Coal Trade.—The following table shews the state of the coal mining industry for four years to 1881 :—

	1878	1879	1880	1881
Number of Mines.......	80	90	107	104
Workpeople Employed....	518	807	1,089	986
Coal Imported, ...Tons.	174,148	158,076	123,298	129,962
	Increase	*Decrease*	*Decrease*	*Increase*
	18,152	*16,072*	*34,779*	*6,664*
Coal Exported, ...Tons.	3,921	7,195	7,021	6,626
		Increase	*Decrease*	*Decrease*
		3,274	*174*	*395*
Coal Produced .....Tons.	162,218	231,218	299,923	337,262
	Increase	*Increase*	*Increase*	*Increase*
	23,234	*69,000*	*68,705*	*37,339*
Coal Consumed.... Tons.	332,445	382,099	416,200	460,598
	Increase	*Increase*	*Increase*	*Increase*
	37,465	*49,654*	*34,101*	*44,398*

This table shews that the increase over each preceding year was :- -

		Per cent.		Per cent.
1878......	Production,	16·7.........	Consumption,	12·7
1889......	"	42·5.........	"	14·9
1880......	"	29·7.........	"	8·9
1881......	"	12·4.........	"	10·6

During 1879 and 1880 the import diminished although the consumption increased, the inference being that native coal was gaining favour and supplanting the imported article ; but in 1881 this progress was not maintained, for not only did the rate of increase in the native production fall off more than half, but the increased consumption had to be met by increased imports—a state of things for which the writer cannot account and which he ventures to think should not have taken place. The returns for 1882 will be awaited with some anxiety, and it is hoped will shew a recurrence of the progress so markedly shewn in 1879 and 1880. Of the 104 collieries working in 1881, only 1 raised over 50,000 tons, 2 over 30,000, 8 over 20,000, and 6 over 10,000 ; the remainder are on a very insignificant scale. The production per person employed in 1881 was in Great Britain 341 tons, and in New Zealand 342.

Quality of Coal.—In a previous part of this paper it was stated that though all the coals of New Zealand are of comparatively recent age, and might be termed Brown Coals, in various states of alteration, yet the qualities are very

various. The following are a few selected (commercial) analyses :—

Locality.	Description of Coal.	Fixed Carbon.	Volatile Matters.	Water.	Ash.	Evaporative Power.
Auckland....	Pitch	50·55	36·52	9·27	3·66	6·5
	Brown	47·45	35·10	15·00	2·45	5.9
Buller	Bituminous	61·75	34·20	2·53	1·54	8·2
	Anthracite	89·01	2·60	3·21	5·18	11·6
Malvern......	Brown	42·19	33·85	19·93	4·03	5·2
Shagpoint	Pitch	42·16	37·60	10·90	9·33	5·3
Kaitangata...	Brown	42·56	36·47	14·93	6·04	5·3

The large quantity of water contained in the hydrous varieties is a very serious drawback to their use for steam and manufacturing purposes. For steam navigation it means bulky stowage and the carrying of a large proportion of an element not only worthless as a source of heat but seriously detrimental to the efficiency of the effective portions of the fuel which are wasted in evaporating this worthless constituent. For manufacturing and steam-raising on shore possibly the conversion of the fuel into heating gas by one of the many gas producers now before the public might mitigate the evil if it did not altogether surmount the difficulty.*

Tenure of Coal Mines.—The ownership is with the freeholder as in England, and in these cases the owner may either work the mines himself or lease them on such terms as may be agreed upon. In some instances the coal fields have been treated as reserves, and the Crown will grant the right of working the mines subject to royalty, reserving a small fixed rent and granting tne use of surface land for the erection of the requisite works. The Government has expended large sums in aiding the adventurers to search for and open mines and in making railway and other works.

Government Inspection.—An Act was passed in 1874 to provide for the Regulation and Inspection of Mines, but for some years remained inoperative owing to the opposition raised by the mining interest. So matters were allowed to

* Should the "Bull" process of smelting iron by gaseous fuel realise the expectations of its inventor, it might meet the needs of New Zealand precisely.

drift on till a terrible explosion occurred at Kaitangata Mine on 21st February, 1878, which caused the loss of 34 lives, every person in the mine being killed. This startled the Colony and awoke the Government to a sense of its responsibility, and on the 28th of the same month the Act was proclaimed in force. Districts have been defined and Inspectors appointed, and since this was done a great improvement has taken place in the management of the mines.

The deaths from accidents of all classes per 1,000 persons employed were in 1881, in New Zealand 8·052, and in Great Britain 1·925: and the tons of coal produced per life lost were, in New Zealand 112,420, and in Great Britain 177,106. These figures can hardly be regarded as satisfactory when we consider the generally simple nature of mining in New Zealand compared with the greater risks incurred in the deep and fiery mines of Britain, and it would seem to indicate room for more skill and more care in the management. Possibly as the mines become individually more important it may be commercially practicable to employ a higher grade of technical skill in their supervision and management, and this may lead to more successful results both in the development of the mines, and in the saving of life.

The coal trade of the colony is yet struggling in its infancy, and one of its greatest difficulties would seem to be the want of better means of communication, more and better roads, more and cheaper accommodation by rail, improved harbours and ports, with specially-built steamers by sea. It certainly is curious that with such splendid resources at their feet the colonists should be content to receive so large a part of this prime necessity from their neighbours; and it is an anomaly to which they would do well to bestir themselves to put a speedy end.

IRON.

The ores of iron are very numerous, more than a hundred varieties being known to mineralogists, but only some of the oxides and carbonates are used for the production of iron,

and to these we will confine our attention at present, They are :—

Magnetite Fe_3O_4 (=metallic iron 72.4 per cent.) not common in England; occurs abundantly in Sweden, and is used for making the famous Swedish iron.

Hematite Fe_2O_3 (=metallic iron 70 per cent.) largely worked near Barrow and Ulverston and used for the manufacture of Bessemer steel.

Limonite, or *Brown Iron Ore* $2Fe_2O_3, 3H_2O$,=(metallic iron nearly 60 per cent. when pure), a widely distributed and abundant ore. That from Lincolnshire and Northamptonshire yields 32 to 37, South Wales 41, and north of Spain about 55 per cent. of iron. The Forest of Dean ore probably contains some Hematite mixed with it as it yields about 68 per cent. of iron.

Siderite or *Spathic Iron*, $Fe.C.O^3$ (=metallic iron 48 per cent.) not much worked in England, but is used in Styria and yields 34 to 48 per cent. iron. Clay Ironstones are impure carbonates, and are extensively worked in Wales, Staffordshire, Shropshire, Derbyshire, Yorkshire, Cleveland, and Scotland, and yield from 26 to 41 per cent. iron. Another variety, the famous Blackband, worked in Scotland, North Stafford, and South Wales, yields 29 to 42 per cent. iron, and contains 20 to 25 per cent. coaly matter.

The carbonates are by far the most important ores worked in Great Britain, and out of fifteen million tons of iron ore mined in 1881 nearly twelve millions were of this class. Although the percentage of metal contained in them is not usually very high, they are kindly ores to smelt, and are found either in the coal fields or very near thereto, and often in immense quantities, as at Cleveland, under conditions permitting them to be mined at a low cost. The two most essential raw materials used in the manufacture of iron being heavy, bulky, and of low value, and consequently unable to bear heavy costs of handling, or large transit charges, their juxtaposition has materially influenced the location of the industry in Britain, and we find all our old centres of iron

smelting established upon coal fields. And similar conditions will most likely affect the localisation of the manufacture in New Zealand whenever the time arrives at which that manufacture can be undertaken with good prospects of success. In our survey of the country we will therefore follow the order we have adopted in describing the coal deposits, beginning with the North Auckland district.

Near Wangarei in the Whau-Whau valley there is a hill said to consist in large part of Hematite, and in a borehole south of Mount Tiger a bed of ironstone 6½ feet thick was proved to be resting on the limestone. At Hikurangi iron ore exists, and at Kawau a brown iron ore occurs in considerable abundance, a sample of which yielded nearly 68 per cent. iron oxides (48 per cent. iron). At Tararu Creek, Coromandel, Hematite is found in abundance and is now being extensively manufactured into iron oxide paint.

South of Auckland and near the Waikato Coal field both oxides and clay ironstones are found. Near Drury and Hunua and at Raglan there are large deposits of granular magnetite cemented by iron oxides into a compact mass. At Maramarua is a deposit of hematite with some magnetite, and brown iron ores in balls are abundant in the coal measures near Raglan. Overlying the coal at Miranda Colliery are bands of clay ironstones.

Abstract analyses of Waikato Iron Ores :—

	Iron Oxides	Manganese Oxides	Carbonic Acid	Siliceous & earthy matters	Water and Loss	Metallic Iron
Drury & Hunua	84·92	2·11	..	8·56	4·41	51·24
Raglan	90·15	Traces	..	8·07	1·78	65·00
„ Coal Measures....	72·69	·56	..	9·12	17·63	50·88
Maramarua....	89·34	..	..	10·66	..	62·30
Miranda (a)....	43·09	..	11·04	45·06	·81	31·10
„ (b)....	50·87	..	32·60	15·95	·58	39 56

Near Taranaki a clayband is found yielding 39 per cent. iron; and a similar kind of ore at Manawatu Gorge, Wellington, contains 38 per cent. iron.

In the South Island, Nelson province is rich in iion ores.

At Dun Mountain and in the Mataura Creek Hematite has been found. At Parapara, near Collingwood, is an extensive deposit of Brown ironstone which has attracted considerable notice and given rise to many sanguine dreams of a future Cleveland in the Southern Hemisphere, only so far to end in disappointment. It resembles a quartz conglomerate, cemented by hydrous iron oxides, but in many parts the ore is almost pure. Large boulders of ore are strewed about the surface, and, for reasons which he gives, and which certainly appear to justify his opinion, Mr. Cox concludes that this is the "iron hat" or gossan of a very large pyritous lode. The quantity of ore is variously estimated at from fifteen to fifty-two million tons. Analysis shews 62·68 iron oxides (equal to 44 per cent. iron.) Portions of this deposit are now being worked for the manufacture of Iron Oxide paint. In the drive at Collingwood Coal Mine several beds of ironstones, somewhat resembling Blackbands, are associated with the coal seams. Two samples gave 61 and 45 per cent. iron oxides (=45 and 35 iron) with 5 to 13 per cent, coaly matter. It will be remembered that the coal from this mine makes good coke, and limestone being also available, attempts have been made to work these deposits. A large amount of money has been expended, possibly not in the most judicious manner, for no success has been attained and the works have been abandoned. A bed of brown hematite is reported to exist at Mount Peel, associated with beds of compact blue limestone. It is of considerable extent, about 50 feet in thickness, and contains 54 per cent. metallic iron. Near Westport are spathic iron ores; and near Grey River nodular masses of clay ironstones are plentiful in the coal measure shales. Of their quality the author has no information, but their proximity to the excellent coking coals of the Grey district would seem to indicate them as worth further examination. At Abbey Rocks spathic iron ore with 26 per cent iron has been found; and hematite from near Paringa River gave 58 per cent. metallic iron.

In Canterbury at Mount Somers, at Malvern Hills, and at Waipara are extensive deposits of clay ironstones, but

ther remote from suitable coal; and at Wakatipu Lake, ago, are several veins of hematite in mica schist: one of 6 t thick, containing sesquioxide of iron 96·11 per cent. =68·8 per cent. iron) with siliceous matters 8.89 per cent.

The available information as to the iron deposits is ither so full nor so definite as a practical man would desire; e attention of the officers of the Geological Survey does not pear to have been specifically devoted to this enquiry xcept in the case of the Parapara deposit), nor does there pear to have yet been any systematic examination made th a view to ascertain if the conditions necessary for sucssful iron making exist.

So far as our present knowledge goes, we see that in orth Auckland there is iron ore, good coal, and limestone close contiguity; in Waikato, good iron ore, limestone thin easy reach, and coal which, though inferior to that ed in England, is yet equal to much that the Germans e successfully for iron-making; at Collingwood, is good ore d limestone, and the coal is of suitable quality if it can be und easily accessible and in sufficient quantity; at the ller and Grey is good coal and limestone in the vicinity, if e ores prove to be sufficiently abundant, and if they can be t cheaply; so that it appears not unreasonable to believe at the iron manufacturer may yet establish himself in New ealand and flourish.

Iron Sands.—From early days the iron sands which occur plentifully throughout the colony have attracted great otice. The beach at Taranaki, between tide marks, almost holly consists of black titaniferous iron sand for many miles length and many feet in depth, and numerous trials have een made to utilise this deposit. It was long believed that tanium imparted some wonderful properties to the steel ade from ores containing it, but this idea is now very enerally questioned. No practical success has resulted from tempts to utilise iron sand for making cast iron; but in merica a kind of Catalan forge is used by which such sands

are converted directly into wrought iron.* Along the West Coast black sands are abundant and are auriferous; and they occur at many other points on the coasts. They are also of very general occurrence in the river beds, and even the gravels and sands when "panned" will often yield them. Though these iron sands are not likely to be of much commercial importance, they are of interest scientifically. They are evidently the result of rock disintegration; those derived from the Diabase and Granite consist largely of Magnetite; those from the Hornblende and Mica Schists, and Palœozoic Slates are chiefly Hematite and Magnetite; while the sands containing Magnetite and Ilmenite are from the Trachytes, Basalts, and Diorites.

Iron Pyrites is of very common occurrence. It is disseminated in small crystals in the Tufanites of Coromandel and in many of the metamorphic schists of the South Island. It is also a common constituent of the various lodes and reefs and is frequently auriferous. In the Parapara River, Collingwood, there is a lode of compact pyrites 8 feet wide, and at Mount Rangitoto is a pyritous lode carrying also galena and gold. Pyrites and Marcasite occur rather too plentifully in the Brown Coal seams of the eastern districts of the south Island, where they are decidedly *de trop*, as they have no doubt been active agents in causing the many cases of spontaneous combustion which have afflicted the owners of collieries working those seams. Pyrites are used for the manufacture of Sulphuric Acid and Green Copperas, but the writer is unable to say if either of these industries is carried on in New Zealand.

*By latest advices (February, 1883) we learn that an attempt is being made at Onehunga, Auckland, to manufacture "blooms" by the American direct process from the beach sands at Manukau, under the stimulus of a Government bonus of £1000 for the first 200 tons of blooms.

LIVERPOOL GEOLOGICAL ASSOCIATION.

April 2nd, 1883.

At the Ordinary Meeting, held this date, at the Free Library, Mr. HENRY BRAMALL, M. Inst. C.E., President, in the Chair, Mr. Isaac Roberts, F.G.S., F.R.A.S., was elected a Member.

Proposed as Members:—

Messrs. Thomas S. Keyte, 18, Chatham Place, Edge Hill; and John Findlow, 42, Percy Street, Liverpool.

DONATIONS.

Three vols. of "Reports of Smithsonian Institution, 1878-80," and "Memoir of Joseph Henry," *from the Smithsonian Institution*, Washington, U.S.; "Proceedings" (Parts 1, 2, 4, 5, 6, 7) Norwich Geological Society, *from the Society;* "Proceedings" (Part 5) Manchester Geological Society, *from the Society*; Paper on "The Formby and Leasowe Marine Beds at Hightown," by T. Mellard Reade, C.E., F.G.S., *presented by the Author*; "Annual Report, 1882, Lancashire and Cheshire Entomological Society," *from the Society*; "Annual Report, 1882, Liverpool Free Library and Museum," *from the Librarian*; Woodward's "Rudimentary Treatise of Recent and Fossil Shells," *presented by Mr. Daniel Clague;* Figuier's "World before the Deluge," translated by Bristow, *complete edition, presented by Mr. Hopkin Thomas.*

A Paper was read on

"THE DRIFT DEPOSITS OF CROMER."

By T. MELLARD READE, C.E., F.G.S., F.R.I.B.A.

The deposits shewn in the Cliffs of Cromer have been of the greatest interest to geologists ever since geology came to be studied from the Huttonian and Lyellian standpoint. Here we have a very complete series of beds ranging from the latest period of the Crag (Weyburn Crag) to the present time. The first published notice of the celebrated Forest

Bed was in 1746 by W. Arderon,* though the teeth of elephants found near Cromer were known from an earlier period; but it is to R. C. Taylor that the first geological description is due, and it is really wonderful how well at so early a date as 1822 and 1827† he grasps the subject. Lyell in 1840‡ also wrote one of the best descriptions of the Drift deposits extant. Almost every geologist of note has written more or less upon the subject, and the latest information we can refer to is contained in the Survey Memoir by Mr. Clement Reid "On the Geology of the Country around Cromer, 1882," accompanied by a very detailed section of the cliffs from Happisburg to Weyburn.

There is, unfortunately, a great deal of discordant information in existence, every observer taking a more or less individual view and differing from those who have gone before and even with himself. Doubtless this is due to two causes—the inconstant nature of many of the beds, the difficulty of examining them except in winter after storms, and then because of the talus, only from time to time, and in places; and, when found, the further difficulty of distinguishing and separating them.

Before describing the drift deposits, it will be well to glance at the beds underlying them. Without endorsing Mr. Clement Reid's section in every particular– for I think there is much that is doubtful and much that will bear a different interpretation to that which he puts on it—we may recognise from the careful way in which the section has been constructed that it will form a good basis for future investigations. There is a great deal both of observation and inference—but especially the latter which permeates the whole in a way difficult to separate—which must be confirmed by others before they can be accepted. More especially is this caution needed when we find that in no one particular, on any subject, does he

* See "Geological Survey Memoir of the Geology of the Country around Cromer," by Clement Reid (page 20.)

† "On the Geology of East Norfolk."—*Phil. Mag.*, 1827.

‡ "On the Boulder Formation of East Norfolk."—*Phil. Mag.*, May, 1840.

unqualifiedly agree with any other geologist. And I may be permitted further to add that there is very little of the con siderable amount of physical theory stated or involved in the Memoir with which I can myself agree.

The succession now given is :—*Chalk, Weyburn Crag, Lower Fresh Water Bed, Forest Bed* (estuarine), *Upper Fresh Water Bed, Leda Myalis Bed, Arctic Fresh Water Bed.* This ends the Pliocene series ; then come the Glacial : *1st Till Intermediate Till, 2nd Till, Contorted Drift, Glacial Gravel and Sand of various ages, Valley Gravel and Loam of Post Glacial age* finishing the whole. The Forest Bed, though the name is retained for an estuarine series from 1 foot to 21 feet thick, is practically abolished, the stools of trees, thought by all other observers to have been rooted in the ground, being looked upon as snags floated down by a river and deposited in its estuary, this river being no other than our old friend the Rhine, of which, to use Professor Hull's phrase, a Palæo-Physiographical Map is given. As I am writing elsewhere on this subject, I shall say no more.*

The Drift deposits I personally examined in 1881† from Mundesley to Weyburn. At Mundesley, after leaving the celebrated Post Glacial Valley cut through the beds, in which interesting mammalian remains have been found, we come upon a chalky Till (Reid's 2nd Till), much resembling what is called the great chalky boulder clay, overlain with stratified sands and gravels, and over these stratified sands are in places gravels that I believe to be post glacial. Beneath this Till the survey section states there occur clay, loam, and sand, with fresh water shells and arctic plants (*Salix Polaris, Betula Nana, &c.*) At one point the upper surface of the chalky clay presented a very defined line of erosion in the form of two anticlinals overlain with stratified gravels. Beyond this was bedded stratified chalky clay overlying the

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* See "Some suggestions on the Cromer Forest Bed." *Geo. Mag.* May, 1883.

† "On the Chalk Masses in the Contorted Drift of Cromer"—Q.J.G.S., May, 1882.

Till, the base being concealed by talus. As we get towards Trimmingham the sands and gravels hitherto roughly stratified begin to be affected by contortions, the first contortion shewing a tongue of the chalky boulder clay (Cromer Till) forced up eastwardly into the sands above. Beyond, the chalky Till takes the form at the surface of a section of a ridge with concave sides, the sands above being contorted, while at the east side they are level and stratified. The next section I have is a sketch of the Southern Chalk Bluff, which is shewn on my diagram. Above this lies chalky Till, with a very distinct contorted line of erosion separating it from the overlying sands which appear to be, a certain distance above, regularly bedded. On the right hand flank of the chalk my sketch shews sand and gravel lying on it. A talus of drift had fallen down through the depression in the centre of the bluff. Up to this section there was a well-markedline of division or erosion at the top of the Till. Beyond this point and before coming to the Northern Bluff, my sketch shews a ridge of chalky Till rising into the contorted sands. We now arrive at the Northern Chalk Bluff, the subject of so much speculation. It is represented in my section sheet figs. 1—4* When I saw it, it was capped with contorted drift, mostly sands, but the base of the cliff of drift flanking it on either side was obscured by talus. I judged the Chalk Bluff projected about 15 yards beyond the face of the line of cliff. I will return to this subject later. Between the Northern Bluff and Sidestrand is seen a banded arrangement of drift lying on Till. It has been pushed up, and even beyond the vertical at one place, as figured, and bent back horizontally and upwards as shewn in figure 6. Another contortion nearer Sidestrand shews a banded bed bent back into the figure S. At various points beyond this, before reaching the tunnel at Sidestrand, are to be seen at the base

* These and the following figures agree with those in my paper on the "Chalk Masses in the Cromer Drift" Q. J. G. S., May, 1882, which can be referred to for the illustrations, as they are numbered as here given.

of the cliff stratified beds of flint gravel with laminated sand and clay of yellow, white, and blue colours. Some of the beds of sands and gravels are false bedded. These beds rise from 5ft. 6in. to 15ft. above the beach. Unfortunately, when I saw these beds they could only be distinguished by scraping the superficial dirt from them, and I had not time to attempt to separate and trace them. On the Survey section they are all classified and coloured together, but it is stated "the upper part of the Forest Bed (shewn in the cliff) is here very sandy and penetrated by small roots." According to the Memoir, the *Leda Myalis* bed does not occur, or rather has not been recognised between Beck Hithe and Mundesley; so this, according to Mr. Reid's interpretation, must all be "Forest Bed", certainly, from what I saw of it a very misleading title.

Between Sidestrand and Cromer the cliff is all of contorted drift. There are two chalk boulders at the base and some masses of reconstructed chalk, quarried for lime, in the contorted drift near the lighthouse.

North of Cromer the drift becomes very much contorted, twisted in all sorts of fantastic shapes, with stratified bands bent backwards and forwards like a ribbon. Side or cross sections which can be seen in places shew that this twisting and knotting is the same at right angles to the cliff. A few yards sliced off the cliff at intervals would shew sections which would vary as much as slabs of figured timber sawn off the bole of a tree. In places the Till is to be seen undisturbed, but in others worked and kneeded up into the overlying contortions. It is here that the enormous masses of chalk are found embedded in the contorted drift. The two phenomena are evidently related as cause and effect. The chalk masses are specially described in my paper, already referred to in the Q.J.G.S., so I need not repeat here what I have there said. Beds of stratified sand are to be traced at the base of the cliff, with in places interlaminations of clay.

The relations of the various beds, basing my views on what

I have myself seen and from a study of the information contained in the Survey Memoir, seem to bear this natural interpretation. The Forest Bed, notwithstanding Mr. Reid's peculiar views, is, I believe, a genuine Forest Bed ; knocked about and denuded it may be. I point to the fact that the forest portion occurs in the greatest profusion at the base. This is evident from the detailed sections of the Memoir. Mr. Savin, of Cromer, also informed me that he had seen hundreds of stumps of trees standing erect on the foreshore, although all those he had seen dug up had roots only a few feet long. Other geologists from the time of R. C. Taylor have seen the same.* These may have been locally moved as happens to some of the stools in our Post-glacial forest bed ; but it is straining at a gnat and swallowing a camel to suppose that the trees could have been cut off in hundreds at a particular level, floated down a river and replanted erect in such profusion. It appears to me the demand to be shewn fibres and small roots is asking for too much proof; we know that these decay and rot more readily than the wood. Geology is full of such difficulties, and often the only course open is to exercise common sense and weigh probabilities. According to my own view, the evidence all points to forest growth *in situ*, after denudation, and the laying down of the estuarine beds with which much of the remains of the forest have been worked up and mixed. The interstratified fresh water beds are only what are commonly met with in estuarine series. The Arctic conditions have undoubtedly supervened between the laying down of the estuarine series and the deposit of boulder clay, and may possibly be represented by a land surface (*Arctic fresh water bed*). The rootlet beds are younger than the estuarine series, but it is not easy to trace them out from the

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* Mr. R. C. Taylor has minutely described the "Fossil trees" and the strata in which they were embedded. He had the best of opportunities for examination during the excavations for the sea wall at Cromer, in 1825, and the evidence he gives of their being in their place of growth seems to me quite satisfactory.—See Trans. of Geo. Soc.—2nd Vol. 2nd Series, quoted by Mr. Henry Norton, F.G.S. in a paper to the Norwich Geo. Soc., May, 1877.

Memoir. Mr. Blake considers the rootlet bed of Kessingland to separate the glacial and pre-glacial deposits in the Cromer cliffs as it certainly does at Kessingland.* This is a probable suggestion and has the merit of being an idea easily grasped, which cannot be alleged of all the theories in the Memoir, though the author deserves credit for his enthusiastic painstaking work.

The relations of the glacial deposits appear to me, notwithstanding the contortions, to be simple enough. First the Till has been quietly deposited in water. It presents no great difference—except in the nature of the materials due to the country rock being different—to our Boulder clay, and, as I have explained the way in which I conceive our Boulder clay has been laid down in my paper on the Drift of the N.W. of England, which will appear in the Q.J.G.S. for May next, it is unnecessary to repeat the substance of it here. That the shell fragments found in the Cromer Till are derivative, if by that is meant derived from older beds, is an assumption with which I cannot agree. Their mode of accumulation, as also of the fragments and "crumbs" found in the Boulder clays of the Yorkshire coast, I consider, founding my opinion on personal examination, was similar to that of our Boulder clays. These fragments, though in many cases of littoral derivation, are yet contemporaneous with the deposits in which they are found.† Mr. David Robertson, than whom there are few better observers, in a recent paper,‡ inclines to the view that the generally unfossiliferous Till of Scotland has been laid down in water, and mentions a bed of muddy sand found under 78 feet of Boulder clay (Till), which contained "shells which were identical with the glacial marine shells usually overlying the thin Boulder clay in the West of Scotland," in which "on further examination echinoder-

* "Proceedings of Norwich Geological Society." Presidential Address by J. H. Blake, Session 1879-80.

† "Drift Beds of the N.W. of England, Part I."—Q.J.G.S., February, 1874.

‡ "Post Tertiary Beds of Garvel Park,"—Transactions of the Geological Society of Glasgow, Vol. VII.

mata, polyzoa, crustacea, foraminifera, and mosses were found, being identical with those met with in the laminated clay above referred to." "This muddy sand bed also contained a large proportion of West Highland rocks, which, we may reasonably assume, belong to the glacial period."* I have shown that some of the Cromer Till at the base is laminated (see section, figure 9); also that there were laminated and stratified bands and beds overlying the Till. The Till appears to have been laid down in quiet water like our Lancashire Boulder clays and after a certain period the conditions came on that produced the contortions, and the previously bedded arrangement of clay and sands and the homogeneous Till were worked up and squeezed into the extraordinary contortions the sections represent. These I have endeavoured to show were produced by the drifting of the ice rafts floating the chalk masses from the cliffs from which they were quarried. For the details I must refer you to the paper on the subject. During the accumulation of these chalk "boulders," sand and gravel and clay were still being deposited and no doubt often on inclined slopes and uneven surfaces which would still more add to the confusion by superinduced current bedding. During the whole period of accumulation from the Till upwards erratics were floated from various points of the compass and deposited in the confused mass. It is worth remarking that those who attribute the most extraordinary, and as it seems to me contradictory, capabilities to the ice sheet, making it, notwithstanding the sub-glacial pasty moraine of Till, &c., on which it rests, force up anticlinals of chalk, then roll them up into boulders, nip them up off the shore and push them up into and along with its mixed moraine of Till clays, sands, and gravels, are still compelled to resort to the agency of floating ice † to bring the igneous erratics to where they are found. Nor has it been explained how on each

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* "Post Tertiary Beds of Garvel Park," page 17 of reprint. See also my Paper on "The Relations of the Glacial Deposits of the Clyde and Forth to those of the N.W. of England, &c.—Ibid, Read 22nd April, 1880.

† See Memoir, page 90.

side of these Chalk Bluffs of Trimmingham—on which so much controversy has been expended—and underneath the chalk boulders are found an undisturbed series of estuarine and other deposits. If the chalk boulders were derived from the chalk of the shore, from which part of it did they come? for we find in most places the remains of the Forest Bed on the foreshore. If from beyond the foreshore, these Newer Pliocene deposits should be found not merely occurring in the Till as small detached masses, but rolled up and distributed over the undisturbed beds and occupying the place of the Till, which in its natural condition is an uncontorted deposit. If the Till was formed under an ice sheet from Scandinavia, as is hinted at in the Memoir, how could the same ice sheet get at the chalk below with a ground moraine underneath many yards thick? And if it were not the same, but a subsequent ice sheet, it would seem strange that No. 2 sheet should act in another manner, avoid ground moraines—although the soft beds of the German Ocean, over which it passed, already provided the materials,—and push the sea bed before it, ripping up anticlinals of chalk, forming chalk boulders hundreds of feet long and forcing the whole along pell-mell.

LIVERPOOL GEOLOGICAL ASSOCIATION.

May 7th, 1883.

At the Ordinary Meeting, held this date, at the Free Library, Mr. Henry Bramall, M. Inst. C.E., President, in the Chair, the following were elected Members :—

Messrs. T. S. Keyte and J. Findlow.

Proposed as a Member.:—

Mr. F. J. Lawrenson, 182, Walton Village, Walton.

DONATIONS.

"Abstracts of Proceedings," Geol. Soc. London, Nov., 1882—Mar., 1883,—*presented by Mr. G. H. Morton, F.G.S.*; "On the strata between the Carboniferous Limestone and Coal Measures in Denbighshire and Flintshire," by G. H. Morton, F.G.S.,—*presented by the Author*; "The Old Red Sandstone," by Hugh Miller,—*presented by Mr. W. Martin;* "Proceedings" Liverpool Astronomical Society, Feb., 1883; Ditto, Manchester Geological Society, Part 6, Vol. 17,—*from the respective Societies*; "Annual Reports," 1881-1882, Birmingham Free Libraries,—*presented by the Librarian.*

Mr. Charles E. Miles (Vice-President), then took the Chair, and a Paper was read on—

"THE MINERAL RESOURCES OF NEW ZEALAND."

By Henry Bramall, M. Inst. C.E.

PART II.

GOLD.

Discovery.—Upwards of 40 years ago Captain Wakefield found gold at Massacre Bay, but the matter attracted no attention till the discoveries at Bathurst, N. S. W. in 1851, stimulated research. A committee was formed in Auckland, and a reward of £500 offered for the discovery of a payable gold field, and this premium was claimed in October, 1852, by Mr. C. Ring, who washed gold out of the Kapanga Creek. A rush of

about 8000 diggers took place, and about 1000 ozs, gold were obtained but the whole enterprise collapsed in about six months; the field was thought to be too poor to pay and was abandoned. Prospecting however continued, and in 1856, gold was found by Mr. Ligar in Mataura River, and by Mr. J. T. Thompson at several places in Otago. In 1861 Mr. Gabriel Reed discovered gold in a gully (since become famous as Gabriel's Gully), leading into the Tuapeka River. The results he obtained were so satisfactory, that a great rush took place, and other valuable discoveries rapidly succeeding, a state of the wildest excitement followed, and gold mining became established as one of the most important industries of New Zealand.

Occurrence.—Gold commonly occurs in the metallic form, never pure, but always alloyed to a greater or less extent with silver. It is also frequently contained in Iron Pyrites, but in what state of combination, or otherwise, is not satisfactorily determined. There are three conditions under which gold is found, 1. Shallow placer or surface alluvial deposits, the beds of present or recent rivers and streams, and sea coasts, 2. Deep placers, or leads, which are cements, or consolidated gravels resulting from the denudation of the rocks containing the gold bearing veins, and are often the beds of ancient glacial rivers. The shallow placers frequently result from the washing, concentration, and reassorting of the old deep placer deposits, by a modern system of drainage differing from the ancient. In alluvial deposits the gold is in the form of scales or flattened grains, and is usually fine, large nuggets being very rare, the largest yet reported is one of 53 ozs found in a creek near Lyell in 1878. 3. Veins or reefs, which are the original depositories of the precious metal, chiefly found in the ancient slates of Silurian, Devonian, or older Carboniferous age, where these have undergone extensive metamorphism, or in the associated volcanic rocks. The gangue is usually quartz and the gold is found in irregular plates and disseminated in small grains, often invisible to the unaided eye. Occasionally filaments or small branch-like forms occur which close examination shews to be built up of minute octahedra. The minerals commonly asso-

ciated with gold in the reefs are the sulphides of iron, copper, lead, zinc, and antimony, and it is noted that lodes carrying much iron pyrites are often the most permanent in yield, and the widest reefs are seldom very rich.

Methods of Mining.—In the early days alluvial gold was separated from the sands and clay of the river beds by washing in a "pan", a shallow wood or tin dish, its great specific gravity rendering this a simple matter. This was succeeded by a variety of cradles, toms, &c., but all these are now almost entirely superseded by the "sluice" which is simply a trough or channel through which a stream of water flows, and into which the earth or "pay dirt" is thrown. The force of the current breaks this up and liberates the particles of gold which are arrested by "riffles" or stops placed at intervals across the trough, while the lighter earth is carried away to increase the "spoil" at the foot of the tail race. Mercury is often dropped in at the head of the sluice which as it trickles down the trough picks up the light grains of gold and forms an amalgam which lodges against the rifles. After running a certain time the feed of water is stopped, and the gold and amalgam collected, retorted to recover the quicksilver, and melted. Hydraulicing is the same in principle as sluicing, the face of the deposit being attacked by powerful jets of water, which break it down and carry it into the head of the sluices. Reef quartz and hard cements are first crushed very fine in stamping mills to liberate the gold, after which they are treated by water and mercury on the same principles as the sluices. There are of course many modifications and variations in the precise methods adopted under differing circumstances, and the treatment of auriferous pyrites is a somewhat difficult and complicated matter, which we cannot stop to consider. The foregoing outline of the general principles, will, it is hoped suffice to render the following notes intelligible.

Distribution.—Gold is very widely distributed over the South Island, but in the North Island it has only so far been found in payable quantities in the part of Auckland lying east of the Thames River and Gulf, extending from Coromandel

Harbour on the North to Te Aroha on the South about 70 miles with a breadth of 15 to 25 miles. This is the oldest gold field in New Zealand having been proclaimed in 1854, and is divided into three districts, North and South Hauraki, and Te Aroha.

North Hauraki or Coromandel.—The Coromandel peninsula is a rocky mountain ridge, traversed by deep precipitous ravines or creeks, and covered by dense timber. The basement rock consists of ancient slates, resting on which are massive igneous tufas, varying in structure from a compact greenstone trachyte or propylite to a coarse breccia of angular fragments embedded in a tufaceous cement. They are possibly of cretaceous age, contain quartz reefs, and at Coromandel are overlaid by brown coal beds, on which are Volcanic rocks of probably Eocene age. The beds of the Tufa formation are decomposed in a very irregular manner, the unaltered rocks rising to the surface in ridges ; and they are usually pyritous. The quartz reefs vary greatly in thickness and where they pass through the soft decomposed beds are usually auriferous, but in the hard undecomposed beds they are sometimes pinched out or become very poor. The associated minerals are blende, galena, manganese, silver, iron and copper pyrites, antimony and occasionally arsenic. The gold is extremely patchy sometimes very finely disseminated, often aggregated, specimens being found which are nearly half gold. The greatest depth to which the reefs have been proved in this district is at the Kapanga Mine 450 feet where the reef is 2 ft. to 4 ft. wide and auriferous. Very rich reefs have recently been found at Tiki, and at Matawai, where 1 cwt. of stone taken from a reef 4 ft. to 5 ft. wide yielded ½ oz. of gold to the pound of stone. The average yield of the district in 1881 was 6 oz. 17 dwts. to the ton of quartz.

The South Hauraki, or Thames District, is at the head of the Thames Gulf, near Shortland and Grahamstown. In general character the country and the reefs much resemble those more to the north. Some of the most successful of the mines are here situated, the dividends realised having been

enormous. For instance, the fortunate shareholders in the Golden Crown, realised £200,000 in one year, and the Caledonian £572,000 in a like period. The Moanatairi in one month yielded 22,555 ozs. gold, the produce for 18 days being 11,148 ozs., of a value of £29,000, all of which came from a block of ten feet square and three feet thick. Water has been a great obstacle in this district, and a large jointly-owned pump has been erected to cope with it. There has, however, been less harmony amongst the contributing companies than their evident mutual self-interest might have been expected to produce, and the pump has repeatedly had to stop for want of funds, resulting in the flooding of the mines. The greatest depth attained is at the Queen of Beauty, nearly 600 feet, at which depth excellent returns were being got when the stoppage of the big pump caused the flooding out of the mine. The Caledonian reef varies from 9 inches to 20 feet in thickness. In the year ending March, 1881, the average yield of this district was 1 oz. 12 dwts. per ton of quartz crushed.

Te Aroha district, in 1881, caused some stir, owing to the discovery of an immense quartz reef, which, at an elevation of nearly 2000 feet, is exposed on the east side of the range. The soft wall has worn away and left the reef exposed, towering up above the tops of the trees in some places, to a height of 100 to 300 feet a wall of quartz 20 feet thick. Five feet of this shews gold in black veins, permeating the stone; the yield being about 2 oz. to a ton. Several other reefs are found adjoining, varying from 2 feet to 4 feet thick, and the existence of payable gold has been ascertained over an extent of one mile along the line of the main reef, and a quarter of a mile on each side.

Hawke's Bay.—The existence of gold-bearing reefs near Mohaka has recently been ascertained.

Wellington.—Reefs are found in the Wairarapa district, in a series of soft black slates, but the yield has not hitherto been satisfactory. Near Cape Terawhiti, in a rubbly sandstone, there are reefs, specimens from which have yielded from 7 dwts. to 3 oz. 17 dwts to the ton, and as the district

is being vigorously prospected, possibly it may become important. The Rimutaka and Tararua ranges hold well defined auriferous reefs, but none have yet yielded gold in paying quantities.

Marlborough. — The gold fields in this province are nivided into three districts.

Pelorous, on the Wakamarina River, about 15 miles from Havelock, where alluvial gold was found in 1864, and a rush took place ; but the easier got gold was soon exhausted, and the place is now almost deserted, only a little sluicing going on, with not very profitable results.

Blenheim or Wairau River is also alluvial, and worked with but mediocre results. In the dividing range between these two rivers gold-bearing quartz reefs are known to exist, and recently one is reported at Dead Horse Creek, 10 to 12 feet thick, of payable quality. The Sutherland reef was worked for a short time, and contained sugary quartz, yielding from 1 grain to 1 oz. per ton.

Queen Charlotte Sound.—Near Picton, some quartz leaders in mica schist and clay slate, yielded 8 to 14 ozs. per ton ; and near Cape Jackson, some well-defined reefs in foliated micaceous schists and blue slates are being worked by the Ravenscliffe and Golden Eagle Companies, with extremely poor results ; the latter, in 1881, crushed 20 tons for 10 ozs. gold.

Nelson.—It has already been mentioned that the first discovery of gold in New Zealand was made by Captain Wakefield, in this province. The field is divided into the following districts.

Wangapeka River, where the gold is all alluvial, and almost exhausted. In 1869, auriferous reefs were found in altered pyritous slate, but are not worked.

Collingwood and Takaka.—In 1856, alluvial gold was found in the Aorere river, which led to a rush, and some rich finds were made, especially in Slate River, and in Bedstead Gully, and other tributaries. The gold is widely disseminated, and only here and there occurs in payable quantities, on the

ridges and crevices of the river beds. It is usually fine, the largest nugget yet found being one of 10 ozs., from Rocky River. In Bedstead gully is the Perseverance Lode at the junction of the blue slates with the felspathic rock, quartz from which yielded 9 dwts. to 1¼ ozs.; and the associated minerals were iron and copper pyrites, galena and blende. An attempt was made to work this lode, but resulted in failure. At Mount Arthur, Takaka, some rich reefs have been recently discovered, and have attracted great attention, steps being taken to commence work upon them.

West Wanganui.—Gold was first found here in 1862, and the field was proclaimed in 1873, but has not been successful; the cement requires battery crushing, and yields only about 5⅝ dwts. to the ton.

Westport and Charleston.—The mining in these districts is all alluvial, and is fairly profitable where sufficient water is available for sluicing. The tailings escaping from the sluicings are reworked by the "fly catchers," who recover the very fine gold carried away with the waste water by "tables" placed in the streams. After storms the grey sand on the beach is swept away, and exposes a thick layer of black sand, consisting chiefly of crystals of magnetic iron, and containing gold, the washing of which affords employment to a number of miners, with very good results. The discovery of reefs is reported up the Mokihinui and Waimangaroa Rivers, and at Cascade Creek, up the Buller River.

Lyell.—Most of the gold in this district is obtained from the alluvial deposits, but remarkably rich quartz leaders and reefs are worked, yielding as much in some cases as 20 ozs. to a ton. The reefs on the ranges between Lyell and New Creek are now worked on a large scale, and yield $10\frac{20}{24}$ dwts. per ton at the United Alpine mine, though some at the Maruia have averaged 3 to 4 ozs.

Inangahua, or Reefton.—This is a very rich district. In almost every gully on the slate bottoms coarse alluvial gold and quartz has been found. Traversing the ancient slates and sandstones, forming the framework of the country, are

numerous quartz reefs, which have been opened and worked with such satisfactory results, as to constitute this next to Auckland the most extensive and important reefing district in New Zealand. The lodes are not usually very wide, but are well defined, and appear to improve in depth. The Golden Fleece Company have a splendid gold bearing reef at 600 feet depth. Considerable excitement has recently been caused by the discovery of rich stone at several widely separated points, the Welcome Mine having yielded in the year ending 31st March, 1882, 13,365 ozs. gold from 3960 tons stone, or 3 ozs. 8 dwts. per ton, paying in dividends £34,500. The general average yield of the district in 1881, was $13\frac{4}{24}$ dwts. per ton, and in 1882, was 1 oz. $6\frac{17}{24}$ dwts. At Cement Town, at the head of Lanky's Gully, is a consolidated quartz gravel or cement, from 1 to 6 feet thick, which was formerly worked, and was abandoned when the reefs were discovered; but the working is now being resumed, partly by crushing and partly by sluicing.

Westland is the most important gold-producing province in New Zealand, all being obtained from the beds of late tertiary or recent age. The gold has originally been derived most probably from leaders and veins in the beds of the Maitai (Carboniferous) Series, which constitute the neighbouring ranges. Enormous denudation has taken place, probably from glacial action, and the detritus has been carried to the bottoms of the valleys, and there spread out by the glacial rivers, the effect of which action would be to "sluice" the gold and cause it to lodge principally in these river beds or bottoms. In some instances there would seem to have been a succession of such actions. At Ross there are 6 of these "bottoms" in a thickness of 400 feet. As glacial action ceased the rivers would begin to cut for themselves newer channels, the tendency of which would be to grow ever straighter and deeper, the accumulated deposits would be left in elevated terraces, and the bends and deviations of the older tortuous river beds would be cut off and left in these terraces. This is precisely how these "leads" are now found; the whole mass of gravels is

sometimes auriferous in a small degree, but it is in the old beds of the rivers that the rich "pay dirt" is found. In many cases pits are sunk, as at Woodstock, where below 50 or 60 feet of gravel is a pay bed from 2 feet to 10 feet thick, yielding from 4 dwts. to 1 oz. to the load of dirt. This is mined and wound by a whip, or windlass to the surface to be sluiced; claims thus worked are known as "Feeder claims". Often long and costly tunnels are driven to reach and drain these leads. At Waimea and Kumara the drift is auriferous for 60 feet deep from the surface, in what has evidently been a bend in the Teremakau river, the present channel of which, is now 60 feet below. In Humphrey's Gully the wash dirt is 100 to 300 feet thick, and auriferous throughout; and so at numerous other localities, the general features being very similar in all. The principal difficulty in working these high level terrace deposits has been want of water, and next to that the disposal of the immense mass of waste or tailings, but many miles of water races and tail races have been constructed, and hydraulicing and sluicing are now extensively and successfully carried on. The districts are Greymouth, Arnold, Ahaura, Waimea and Kumara, Kanieri and Hokitika, and Okarito, in none of which has quartz mining yet been established. In Greymouth, near Brunnerton, is the remarkable lode known as Langdon's, 9 feet wide, 2 feet of which is compact auriferous stibnite, the remainder being quartz carrying stibnite, and a little gold. Near Kanieri is a well defined reef 10 feet thick, and near Waimea several leaders from 1 to 5 feet thick, the stone carrying visible gold. The district will probably become an important reefing one when the present alluvial workings begin to shew signs of exhaustion.

Otago.—The schistose rocks, which are believed to have been the original repository of the gold-bearing veins, constitute the solid geology of about half this province, but so great has been the glacial denudation which they have undergone, that they are rarely seen at the surface, being hidden by the terraces and plains formed by resulting gravels and detritus. These gravels are almost always auriferous, though the gold

is not uniformly disseminated throughout, some parts being richer than others. In some instances the gravels are compacted, and form cements requiring to be crushed to liberate the gold. In many cases the gravels have been washed, reassorted and rearranged by the present rivers and streams, (which follow a course differing from the ancient drainage system of the country), and the gold has been so concentrated as to form very rich deposits. These are the River and placer diggings, which, since the discoveries of Gabriel Reed, in 1861, have yielded such fabulous riches, and the gold in these is often associated with platinum, zircons, garnets; black hematite, and scheelite. The province is divided into the following districts.

Hindon, near Dunedin. The alluvial gold is almost exhausted. Several well defined quartz reefs are known, and have been worked, but the yield was not considered satisfactory, and the mines are closed.

Tuapeka, on the north of the Clutha River, chiefly alluvial workings. The cements of this district lie in basins in the hollows of the older schists, and are often from 60 to 300 feet thick, shewing "color" of gold throughout, but the payable parts being somewhat patchy. These have been tried by working the whole mass by hydraulicing and ground sluicing, and also by selecting the richer parts for battery treatment; but the results have not been satisfactory, and they are now almost abandoned. At Gabriel's Gully an attempt is being made to rework the immense deposits of tailings left from former earlier diggings, by sluicing on a large scale with Perry's hydraulic elevator, and should this turn out a success, it will probably cause a revival in many districts now nearly abandoned. At Waipori are reefs yielding from 10 to 19 dwts. per ton, worked on a small scale. *Waikaia* is an alluvial district only.

Oamaru and *Mount Ida* districts are chiefly alluvial, and most of the surface deposits shew diminishing yields. Hydraulicing is followed in some cases, but the results are

not very profitable. At Serpentine some reefs are being opened with encouraging prospects.

Dunstan and *Wakatipu* districts give employment to a large number of alluvial miners, the Clutha River throughout its course and its tributaries, being all auriferous, though much of the easier worked ground is becoming exhausted. The bed of the Clutha is worked by floating dredges at many points, and in some cases with considerable profit. But the future prosperity of these districts will probably largely depend on the working of the reefs near Cromwell, Macetown and Shotover. These are contained in laminated mica and clay schists, which form a broken and mountainous country, with valleys three or four thousand feet deep. At Macetown there are five or more well defined reefs, bearing nearly N. W., and varying from 2 ft. to 14 ft. wide. The matrix is quartz and breccia, the quartz carrying free gold and auriferous pyrites, in irregular shoots, richest where the pyrites are most abundant. The general yield has been from 1oz. to 1½oz. to the ton, though some of the leaders have given as much as 5 ozs., and 300 tons crushed by the Maryborough Company, in 1881-2, yielded 4 ozs. per ton. So great is the elevation of this country that work cannot be carried on for at least five months in winter; and the want of roads is a great hindrance to the proper development of the mines. At Shotover there is a reef 12 feet wide, which, however, has not yet proved very rich.

Longwood.—Some alluvial mining is still carried on here and some reefs, not very well defined, bearing N. W., intersect the slates, conglomerates and breccias of the Longwood range, the gold being extremely patchy, and no very successful results having been attained, so far.

Fineness.—As already mentioned all gold is alloyed with silver, and the degree to which this obtains, varies greatly in New Zealand, alluvial being as a rule finer than reef gold. That from Otago is 22¼ to 23 carats fine, equal to 92·57 to 95·98 per cent; while from the Thames, Mr. Skey examined 12 samples, the results being gold from 43·2 to 60·6 per cent,

and silver 56·8 to 39·4. Yet, some alluvial gold from the latter district was 22 carats fine or 91·66 per cent. the reason of which is not very apparent, unless we may suppose that the ore contains some silver which the mercury used in amalgamation picks up along with the gold. The gold from Otago Westland, and S. W. Nelson is valued at £3 15s. to £3 17s. 8d. per oz.; from Collingwood and Marlborough, £3 10s. to £3 13s.; and from Auckland, from £2 5s. to £3 3s.

Yield of Quartz.—In the prospectuses issued by the promoters of gold mining companies, it is very common to give statements of the yield per ton of quartz, and from the analyses made at the Colonial Laboratory at Wellington many startling bits may be culled. As many credulous investors have had reason to learn, a few ozs. or pounds of picked specimens no more make a valuable and paying mine than one swallow makes a summer. However as curiosities in their way the following may be cited. Quartz from a lode at the Thames gave 1335 ozs. to a ton, a micaceous rock from Cromwell 23 and 30 ozs., Iron Pyrites from Dunedin 70 oz., Quartz from Lyell 71 oz.

The average yields per ton for the three years to 1881 are

Auckland	1oz. 10dwts.	to	1oz. 17dwts.
West Coast	13 ,,	to	16½ ,,
Otago	10 ,,	to	18½ ,,

This compares very favourably with Victoria, where the average yield for 6 years from 1874 to 1880 was 10dwts. In New South Wales in 1879, the average yield was 1oz. 5dwts. per ton.

Production.—The importance of the gold mining industry to this colony, may be appreciated by the fact, that from April 1857 to June 1882 the exports of gold have amounted to 9,910,210 ozs. of the value of £38,666,278, an average per year of £1,531,337. Of late years, this average has not been reached, the export in 1881 being valued at £1,080,790. In March, 1881, the population of the Gold Fields was 57,107, 11½ per cent of the entire white population, and 15,063 were actually engaged in mining; while the value of the plant employed was

£429,314, and the expenditure on over 5000 miles of water races &c., tots up to a million and a quarter more.

Tenure of Gold Mines.—Subject to regulations, there are open more than ten million acres of Crown Lands, on which miners have the right to search and mine for gold, and to occupy whatever portions they may select for purposes of mining or residence. For these privileges, they are required to pay one pound per head for miners right, and one pound per acre for ground occupied on mining lease, with some nominal fees for registration of water rights and other mining property.

Administration.—The Acts, amendment Acts and amended amendment Acts, passed for the regulation of gold mining in New Zealand are very numerous, and stand in need of consolidation and codification. Since the Act of 1877 a departmental office under the Minister of lands, has been established at Wellington, and has under its control all officers on the Gold fields, including the Wardens of each district, Receivers of Gold Revenue, Mining Registrars and others, and is charged with the maintenance of all Government constructed water races.

Future Prospects.—About two thirds of the gold now produced in New Zealand are derived from alluvial deposits, but reefing is becoming more general, and certainly contains the elements of greater permanency than alluvial mining can be expected to afford. There is plenty of stone yet unworked, as rich as that which yields good results in Australia. but which dear labour and a difficult country, prevent from being profitably worked at present. The great want is better means of communication to open up the country, and facilitate transit, and so cheapen the present heavy costs of mining, and there can be no doubt that this would give a great impetus to an already very important industry, and render it the source of permanent benefit to the colony.

SILVER.

Although a notable quantity of silver is produced in New

Zealand. ıt is all found either as an alloy with gold, or in galena. Small fragments of native silver were obtained in the diggings at the head of Wakatipu Lake, in 1864, and at Waipori, and the Colonial Museum contains a specimen of Argentite, which came from the Silver Crown Claim at the Thames. A specimen procured from Grahamstown was an argentiferous ore associated with auriferous quartz, and, by amalgamation, gave 22 $\frac{19}{20}$ ozs. gold alloyed with 70 ozs. silver, and a further 309 ozs silver, which was probably in the state of a double sulphide of silver and lead. A vein of silver lead occurs in Ohio Creek, Thames, and in a gully near the hot springs on the West face of Te Aroha mountain is a known silver lode, but little has been done to prove its value.

In Collingwood, at Richmond Hill, there is the most important discovery of silver yet reported. In 1875, a sample from this place was sent to the Colonial laboratory, to be examined as an Iron ore, but proved to consist of Sulphides of Lead, Antimony, Copper and Iron, and gave 185 ozs. silver to the ton. It was taken from a vein crossing the Parapara river, about five miles above its mouth. The country rock is gneissic schist, and the lode is from 20 inches to 2 feet wide, carrying a rib of solid compact ore from 3" to 7" thick in a gangue of quartz, and some chalcopyrite, yielding 150 ozs. silver to the ton. The centre rib is a new mineral, a variety of Fahlerz or Tetrahedrite, for which the name Richmondite has been proposed. It is of massive subcrystalline structure, brittle, cleavage irregular, color black or reddish, streak dark slate, H. 4·5 ; S.G. 4·317 ; fuses with intumescence at a little under red heat. Mr. W. Skey gives the analysis as—

Sulphide of	Lead	36·12
,,	Antimony	22·20
,,	Copper	19·31
,,	Iron	13·59
,,	Zinc	5·87
Silver		2·39
Manganese		·52
Bismuth		*Trace*

and states the formula to be. $Sb^2 S^3 + 6(Pb.Cu.Zn.Fe.Ag.)S$. The formula of Fahlerz is $(Sb.As.) S^3 + (Cu Zn. Fe.Ag.)S$. Explorations were commenced which shewed the lode to be well defined, but the ore was patchy, and in depth became a mixture of iron and lead sulphide, the galena giving from 21 to 163 ozs. silver only, whereas the Richmondite had yielded from 100 to 1,792 ozs. The results were not considered such as to warrant the commencement of systematic mining operations with any prospect of profit, and the works were closed, and at latest advices so they remain. Dr. Hector, writing in 1881, attributes the failure to the want of power drills.

In Westland, at Mount Rangitoto, 20 miles south of Hokitika, there is a lode 10 inches thick, cropping on the face of the mountain, at the junction of the granite and slate, and carrying pyrites and argentiferous galena. Considerable excitement was caused in the colony by the publication of assays of this ore, which stated the contents of silver to be 735 ozs. and 392 ozs. per ton, and on these a company was projected to buy and work the property. The colonial analyst, Mr. Skey, thereupon procured authentic samples from the lode, but could only obtain 43 and 45 ozs., and from subsequent samples, only 7 to 28 ozs. These results were borne out by those of Professor Bickerton, Christchurch, of Mr. Isaac Lewis, Westland, and of the Royal Laboratory, Harzer Smelting Houses, Germany; and Mr. Skey deserves credit for having by his prompt and praiseworthy action in the matter, saved the pockets of the investing public, and prevented a rude blow being inflicted on the *legitimate* development of Colonial mining.

COPPER.

The most abundant and important ore of this metal is the double sulphide of copper and iron, known as copper pyrites, $Cu. Fe. S_2$ * which, when pure, contains about 34 per cent. metallic copper. It is usually found so mixed and

* Cu. 34·45, Fe. 30·57, S. 34·98.

interspersed in the gangue of the lode, that it is more economical to treat the stuff without incurring much expense in dressing to a high per centage, Cornish ores being seldom dressed to more than from 6 to 8 per cent. metallic copper. Of less, though still considerable, importance, are native copper, copper glance, cuprite, and crysocolla. Copper in all these forms exists in New Zealand.

In Auckland, at Kawau, the earliest discovery was made, a mine being opened in 1842, on a well defined lode 8 feet wide, which was worked to a considerable extent. The ore was copper pyrites, which yielded at first 16 per cent. but fell afterwards to 5 per cent. It was shipped without selection, or any attempt at concentration, and after about 2000 tons had been extracted, the mine was abandoned and has never been re-opened. At Great Barrier Island the Otea Mine was worked for some years in a breccia lode carrying copper pyrites with some carbonates and black oxide, assaying 24 to 28 per cent. metallic copper. The mine was opened by a local Company, and then passed into the hands of an English Company, who erected very costly machinery; but after producing 2,323 tons, this shared the fate of the Kawau. Dear and scarce labour and fuel are the causes to which these failures are attributed.

In Nelson, at Dun Mountain, the Maitai slates rest upon serpentine, which passes into Dunite, an olivine rock, closely resembling Lherzolite, and in the serpentine numerous irregular pockets of cuprite and native copper have been found. So long ago as 1856, a consignment of these ores was sent to England, and resulted in a Company being formed to work the mines. It is said the capital of the Company was frittered away, without any systematic exploration of the ground being made, but there does not appear to be any evidence that any true lodes exist in this district. One thing is c rtain, the operations of the Company were unsuccessful, and the mines have been closed and abandoned for many years. Quite recently, a Mr. Newport has been prospecting the ground, and discovered several outcrops, but nothing,

apparently, very encouraging. In the Aniseed Valley a lode has been discovered, and traced for some distance, by Mr. Stratford. It is named the Champion lode, is 5 feet wide, and carries cuprite and native copper, and some specimens are reported to have yielded 90 per cent. of metal. In Hacket Creek, there is a remarkable deposit, consisting of a dark green granular serpentine, in which are embedded numerous grains of metallic copper, amounting to from 2 to 6 per cent. of the whole mass. The belt of serpentine which occurs at Dun Mountain extends northwards to Croixelles, and through D'Urville Island; and the existence of copper in this serpentine at the South end of the Island has been known since 1859. Recent explorations have revealed the presence of at least two well defined lodes, though the ore deposits are very patchy and irregular, varying from 1½ to 6 feet in thickness, and being sometimes pinched out altogether. The ore near the surface is cuprite and native copper coated with carbonates; somewhat deeper it becomes copper glance, while at the lowest depth yet attained the sulphide is mixed with native copper. The produce varies from 6 to 24 per cent., but there would appear to be no difficulty in dressing it to say 25 to 45 per cent. Fifty tons, from near the surface, and only imperfectly picked, were sent to Melbourne, and smelted, yielding 10 per cent metallic copper. At the Pioneer claim, Bedstead Gully, near Collingwood, a band of quartzose schist in the felspathic rocks is traversed by thin bands of quartz, carrying copper pyrites, worth 29 per cent. copper, but the ore was found to be so patchy and irregular that the working was unremunerative and was abandoned.

In Westland, in the beds of several rivers near Mount Cook, rolled pieces of copper pyrites have been found, but the lodes whence these have come have not been traced. At Paringa River, near Jackson's Bay, Mr. McFarlane reports the discovery of a well defined lode at the junction of the mica schist and slate. It is 3 feet wide, of which one half is a solid rib of pyrites, yielding 18·5 per cent. copper, the remaining half being quartz with strings of pyrites. Other samples

from this locality have given 19 to 26 per cent. The same gentleman sent a sample of copper glance from Big Bay to the colonial laboratory which assayed 67 per cent. metallic copper.

In Otago, at Reedy Creek, Waitahuna, a lode was discovered by some diggers who had "wingdammed" the stream in pursuit of their occupation of gold washing. The country is grey quartzose or mica schist and the lode which is 4 feet wide, carries copper and iron pyrites assaying 14 to 18 per cent. A company which has undertaken to work this lode, has just completed the necessary machinery, and will shortly test the commercial value of the discovery. At Moke Creek, Wakatipu, a strong lode is known, 4 feet wide, with a rib 5 to 8 ins. thick of solid pyrites assaying 11·57 to 25·60 per cent. copper. At Dusky Sound, near Mount Solitary, a Mr. Docherty discovered a deposit containing copper pyrites at the foot of a spur or razorback ridge over 600 feet high, and on the summit traced what seemed to be a lode. On blasting away the acute top of the ridge, the lode became small strings running into the subjacent rock, and it appears not unlikely that the spur is really the foot wall of a great lode, the hanging wall and the lode itself having been denuded and fallen away. Samples taken from the fallen masses yielded from 3 to 18 per cent. copper. The lode has been traced some distance, and there are indications of the existence of others in the neighbourhood.

MANGANESE.

The ores of this metal are somewhat widely distributed, and those which are of commercial value—Psilomelane, Manganite and Wad, occur at several places in workable quantities of good quality.

In Auckland, about 4 miles from Russell, Bay of Islands, manganese ore is found outcropping in boulders in the slates of the upper Devonian, which form the cliffs on the River Waikare, and mines have long been worked, and now employ about 50 men, and produce about 1500 tons per year. At Waiheke Island there are mines which yield about 40 to 50

tons per week. The ores are massive Manganite and Psilomelane and some Wad, and have the following composition:—

	Manganite.	Psilomelane	Wad.	
	Waiheke.	Bay of Islands	Bay of Islands.	
			a	b
Sequioxide Manganese..	88·24	75·46	40·9	87 47
Ditto Iron	·59	11·76	8·6	....
Siliceous Matter	·58	2·74	22·4	·42
Water	10·59	10·04	28·1	12·11

The other places in Auckland where Manganese occurs, are at Kawau, (where it was formerly worked); at Pakihi Island in numerous small veins traversing the slates; at Whangarei; at Waipu; and in the Coromandel peninsula, associated with the gold reefs.

Near Wellington, at Terawhiti, Manganite has been found; and at Ohario, it occurs in a thick lode, traversing the slates and sandstones of the district, the composition being:—

	Terawhiti.	Ohario.
Sesquioxide of Manganese..................	87·36	82·72
,, Iron..........................	1·42	1·76
Siliceous matters............................	·60	4·62
Water..	10·62	10·90

Absolutely pure Manganite ($Mn_2 O_3$, $H_2 O$.) would contain 89·9 of Sesquixoide of Manganese and 10·1 water.

Manganese ores are known to exist, though not yet ascertained to be in workable quantities, near Napier; in Nelson province, at D'Urville Island, and Bedstead Gully; in Marlborough, at Tory Channel; in Canterbury, at Malvern Hills, and in the Upper Waimakariri; and in Otago at Kawarau, Clutha, and Dunstan.

The large market in England for ores of good quality has stimulated research, and will no doubt lead to further discoveries. The quantity exported in 1881 was 1271 tons, valued at £3,283, an average of £2 11s 7d per ton.

ANTIMONY.

The only ore of this metal which is of commercial importance is the sulphide Stibnite, $Sb_2 S_3$. (Sb 71·77. S 28·23). The chief supply has hitherto come from Borneo, and a little from Hungary; but it is found in abundance at widely separated points in New Zealand.

In Auckland, at the Thames, many of the reefs have yielded fine characteristic examples of interlaced crystals, as well as massive forms; and it occurs also at Bay of Islands. It is reported also from Napier, and from the Tararua Range, Wellington.

In Marlborough, at Endeavour Inlet, Queen Charlotte's Sound, considerable blocks of ore occur scattered through the surface deposits, and in 1872, several lodes carrying compact stibnite and quartz were discovered. The country rock is a fine-grained greenish schistose rock, and the principal lode worked upon was 3 to 4 feet thick, and very persistent, being traced for over five miles in a W.N.W. direction. The produce varied from 17·2 to 69·4 per cent. stibnite, but in depth the lode changed into a poor auriferous quartz reef Some boulders from a water course at Gore Bay, Pelorus Sound, gave 82 per cent. stibnite in a quartz matrix.

Near Greymouth, on the East of the Paparoa range, is the Langdon reef, already mentioned under "Gold." The country rock is a hard blue cherty slate, and the reef has the following structure:—

	Feet.	Ins.
Slate breccia	1	8
Fine grained quartz and stibnite	0	4
Stibnite with quartz nodules	3	0
Compact stibnite	2	0
Quartz with patches of stibnite	2	0

Foot wall—slate.

In Otago, at Stony Creek, near Waipori, in a country composed of friable decomposed schist, there is a lode 2½ feet wide, carrying quartz with fibrous and compact stibnite, and a little peroxide of iron. A lot of four tons shipped

gave a return of 47 per cent. Antimony. Vigorous measures are being taken to open up the mine, and the produce is to be shipped to London. The district is so inhospitable that probably no work will be possible for three months of the winter. At Hindon, on the summit of a spur in mica schist, is a quartz lode 18 feet thick, with patches of stibnite; and at Alexandra, on the west bank of the Clutha River, a "very fair lode" has been recently discovered. The existence of a lode near Shotover has been known many years.

CHROMIUM

is somewhat extensively used in the arts, the market being principally supplied from Shetland. It occurs in the province of Nelson as Chromite (chrome iron ore), and was discovered in 1861, by Mr. Hacket, at Aniseed Valley. The Copper Mining Company, at the Dun Mountain, during its short career, worked and exported about 5,000 tons of this ore. It is found in a black granular, and in a brownish black compact form in irregular bands in the serpentine rock; and also as a constituent of Dunite, a hard crystalline olivine rock, occurring in bands, and containing disseminated crystals of chromite, in quantity varying from a few grains up to nearly half the whole mass. The band worked by the Dun Mountain Company is 10 feet thick, and that of the Roding River Company 15 feet thick, proved to a height vertically of 300 to 400 feet. The samples examined at the Colonial Laboratory have given from 30 to over 64 per cent. chromic oxide ($Cr_2 O_3$). Some of the deposits are, unfortunately, in positions so very difficult of access that there is little likelihood of their being profitably worked at prices now realised by the ore.

LEAD AND ZINC.

The ores of these metals are so frequently associated in the same lodes, that it will be convenient to consider them together. Of all the numerous forms in which lead occurs in nature, two only occur in sufficient abundance to be worked as sources of the metal, and these are the sulphide Galena (PbS=Lead 86·6 per cent.) and the Carbonate. No discovery

of the Carbonate has yet been reported in new Zealand, but the existence of Galena has been known since 1859, when Dr. Hochstetter is said to have procured specimens from the Kaimanawa range, south of Lake Taupo, and it is now known to be pretty widely distributed. The only zinc ore yet discovered is the sulphide Blende, (Zn. S=Zinc 66 per cent.) On the Tararu Creek, Thames, a quartz reef, formerly, near the surface, richly auriferous, proves deeper to carry considerable quantities of Galena, the ore assaying 40 per cent. lead, with some copper, silver and gold. Blende also occurs here. At Tiki, ore has been found giving Zinc 46·1, Lead 13·4, with a little copper and silver. And at numerous claims in the Thames field, as well as at Great Barrier Island, Galena and Blende are of frequent occurrence.

In Wellington, in the Upper Tararua District, West Wairarapa County, water worn fragments of galena and blende have been found in the bed of the stream, but the lode whence they were derived has not yet been traced.

In Nelson, at Wangapeka, at the Wakamarama range, and at Mataura Creek, argentiferous galena occurs mixed with quartz; and blende at the Mount Arthur gold reefs. The most important deposit yet found is at the Perseverance Mine, near Collingwood. The main reef is 2½ to 6 feet thick, filled with quartz and slate breccia, and, as already mentioned, when worked for gold, resulted in failure. But at about five feet above this reef is a band 5 feet to 6 feet thick, of blende and galena. The former varies in color from black to light yellow, and yields from 59 to 65 per cent. of zinc. After remaining closed for many years, the mine has been again taken up, with a view to working this band.

In Westland, near Hokitika, at Abbey Rocks, and the Paringa and other rivers, galena has been found; and also at West Taieri, in Otago.

TIN

has been long and eagerly searched for, and Dr. Hector states that the first trace of Cassiterite was discovered in July, 1870,

in black sand, from the upper part of the Buller River. In 1876, Mr. Blair, C.E., sent a sample of stream Tin to the Colonial Laboratory, which was stated to have been obtained from the auriferous gravels of Tuapeka district. These discoveries were not confirmed; but in June 1881, a sample of sand taken from the tailings from the auriferous cements at Lanky's Gully, Reefton, was sent to the Colonial Laboratory, and, on examination, was found to consist of iron pyrites, titanic iron, and about 20 per cent. cassiterite. This discovery points to the existence of the mineral in the adjoining mountain ranges, and should stimulate further research, and may possibly lead to results of great importance.

MERCURY.

On the south of Omapere Lake, about 15 miles west of Bay of Islands, there is a conical hill, whence has flowed a stream of scoriaceous lava, from whose terminal end steam still escapes. Near by are the Ohaeawai sulphur springs, forming a small lake of four or five acres; the waters from which deposit a loose siliceous brown sand, in layers, enclosing fragments of plants, and containing thin beds of cinnabar sand, and globules of metallic mercury. The layer containing the mercury is only four inches thick, and confined to a limited area, so that attempts to collect it have not been profitable. From the same locality a specimen of impure Idrialine cinnabar has been procured, resembling in appearance a dark fine-grained brown sandstone, containing 30 per cent. mercury, and 21·5 of Hydrocarbons; an interesting discovery, inasmuch as Idrialite had previously only been known to occur at the cinnabar mines of Idria.

In Otago, at Waipori, Serpentine Valley and Dunstan, rounded grains of cinnabar have been found in alluvial deposits, but the source whence they were derived has not been traced. Last year very promising samples of cinnabar were discovered at the Upper Nevis, yielding 84 per cent. quicksilver. In a country so largely employed in gold mining the finding of mercury in payable quantities would be of

immense benefit, and it is much to be desired that further explorations may lead to this result.

ARSENIC

has been found native at Kapanga Mine, associated with gold, and is believed to interfere materially with the amalgamation process. Near Greymouth, at about 800 feet below the Langdon reef, there is a lode of arsenical and auriferous pyrites; and detached crystals of mispickel are of not uncommon occurrence in many places.

COBALT AND NICKEL.

Cobalt has been detected, but in quite insignificant quantities, in Wad, from Auckland; and Erythrine is reported from the West Coast of Otago.

Nickel to the extent of 2·98 per cent. was found in Pyrrhotine, from Richmond Hill, Collingwood; and a mass of serpentine rock, near Mahurangi, gave 1·81 per cent. Oxide of Nickel; but these quantities are too small to be of any present money value.

METALLIC MINERALS OF MINOR IMPORTANCE.

Tungsten.—The mineral Scheelite ($Ca\ O, WO_3$) Tungstate of Lime was first identified by Dr. Hector, in Buckle Burn, near Lake Wakatipu, where it occurs as coarse heavy white sand, which the diggers found it difficult to pan off when washing for gold, and which they dubbed "white maori." Mr. McKay has found the mineral in sitû in a quartz reef at the junction of the chlorite schists, and blue slates on the west side of the Richardson Mountains.

Molybdenum has been discovered as Molybdenite at Dusky Sound; and a sample of Wulfenite was procured from Dun Mountain.

Titanium occurs as Ilmenite in many of the iron sands at various localities.

Bismuth.—No ore of this metal has yet been found, but traces were noted in the analysis of Richmondite from Collingwood.

Platinum has been found in small flat grains of a steel grey or silver white color, at the Collingwood gold fields; and *Platiniridium* and *Osmiridium* have been obtained, in very small quantities, from the gold washings at Takaka.

The metals, no trace of which has yet been discovered, are Uranium, Cadmium,* Tantalum, Tellurium, Palladium, Cerium, Vanadium, Rhodium, Lanthanium, Columbium, Niobium. and Pelopium; most of which, however, are of very limited use, and are little more than merely scientific curiosities.

GRAPHITE

occurs in rocks of the most ancient formations, and has two distinct forms: 1—the amorphous, fine grained, as at Borrowdale; and 2—the granular, which is composed of small flat plates, as the Ceylon variety. It is largely employed for the manufacture of refractory crucibles, for which purpose it is mixed with from 50 to 75 per cent. fireclay. That used in England is chiefly brought from Travancore, Ceylon, the best native samples of which contain 95 to 100 per cent. Carbon, the impurities being usually small quantities of silicates.

Graphite is found in New Zealand, at Waiokura Creek, Waimate, of very homogeneous character, containing 86 to 92 per cent. Carbon; a lode is said to have been recently found at Coromandel; and, from near Mount Egmont, water-worn masses, with 61 per cent. Carbon, have been obtained, indicating the presence of a yet undiscovered deposit in the vicinity. Graphitic shale is found at Waitotara; and from an undisclosed locality, about 14 miles from Wellington city, a graphitic mineral, containing 66 per cent. Carbon, is reported.

The most important locality, however, is at Pakawau, Collingwood, where the brothers Curtis, in 1861, discovered and commenced to work thick beds of graphite shale, interstratified with metamorphosed shale. The graphite is of the amorphous and valuable variety, containing from 37 to 58 per cent. Carbon, and is somewhat extensively worked and manufactured. At other points in the neighbourhood. graphite

*This metal is often present in small quantity in Blende.

minerals yielding from 22 to 66 per cent. carbon have been found. Graphite shale occurs at the Malvern Hills in Canterbury; and from Clyde, Otago, specimens yielding 45 per cent. Carbon have been procured. The mineral is also known to exist at Dusky Bay.

PETROLEUM.

At Pakakea Whirikoka, about 30 miles from Gisborne, Poverty Bay, there are some springs, in small circular basins filled with water, from which bubbles of gas arise, and petroleum collects on the surface. At several points from here to Gisborne, oil exudes from the ground. Dr. Hector points out that these oil escapes appear to be always associated with the middle secondary formations, and he considers that the oil of the East Coast deposits, is most probably derived from bituminous shales of upper Jurassic age. The oil resembles that found in Canada. A company was formed in 1873 to work these springs, but was not successful.

A more promising district is that of the Waiapu, whence Mr. Rice in 1866, obtained excellent petroleum; and the Maori Chief Ropata, in 1872, collected at Manutaki, in this district, very valuable limpid, palebrown, nearly transparent oil, of a specific gravity of ·829, and indicating a yield of 70 per cent. of burning oil. An extensive deposit of a soft mineral grease is associated with the petroleum rocks of Waiapu, which as tested on the large scale by the Southern Cross Petroleum Co., gives, Light Oil 5·4, Kerosene 13·2, Lubricating Oil 4·0, Paraffin 7·9, Residue 69·5. This is a product formed by the petroleum, overflowing from the natural oil springs. Mixing with the soil, the lighter constituents have evaporated, while the oily portions have been oxygenated, and have absorbed water, thus becoming converted into a variety of Dopplerite, and this remains with the paraffin, which is unaltered.

A very similar deposit occurs at Waipara.

Petroleum oil is known to exist in the country between Hick's Bay and East Cape, at present in the hands of the natives.

At Taranaki, small quantities of petroleum have at times been collected from the cracks and fissures of the rocks.

Oil Shales.—Reference has already been made to the finding of an excellent specimen in the North Auckland district, the parent bed of which has been sought for so far in vain. Recently a discovery of Kerosene shale was made near Collingwood, containing 79¾ per cent. Hydrocarbons ; if this exists in quanity, it ought to prove a most valuable find. The consumption of Kerosene oil in New Zealand in 1880, was 690,041 gallons, so that a large and increasing market awaits the discoverer and manufacturer of this important product.

KAURI.

In the northern parts of Auckland, and there alone, for it is unknown in any other part of the world, flourishes the magnificent Kauri pine, from whose twigs and branches oozes a white transparent gum, which hardens on exposure to the atmosphere, and becomes of a bright yellow colour, resembling amber. Formerly extensive tracts of this part of New Zealand were covered by forests of Kauri, which have perished, probably by fire, and on their sites, buried 2 or 3 feet beneath the surface, are found large deposits of fossil Kauri gum, in lumps of all sizes up to 30, 60, and occasionally 100lbs. weight.

Kauri gum becomes plastic at 180° Fahr : and can then be moulded into any form. It has a specific gravity of 1·047, burns readily with a clear luminous flame, giving off a light pleasant aromatic odour, and becomes electro-negative by friction. It is dissolved by concentrated Sulphuric Acid coloring the solution red.

Kauri gum is largely used for the manufacture of varnishes ; and many of the *amber* mouthpieces which adorn the " Smoker's friend" would, if their pedigree were curiously inquired into, be found to have sprung from a New Zealand pine tree. The trade in this article is a very large, important, and increasing one, the exports being given as,—

	Tons.	Value	Value per Ton.
1878	3410	£132,975	£38 19 10
1879	3247	£147,535	£45 8 9
1880	4724	£242,817	£51 8 0
1881	5460	£253,778	£46 9 5

The value has been steadily rising; in 1860, the average was £9 8s. 4d. per ton; in 1870, it was £34 16s. 6d.; and in 1880, it reached as stated above £51 8s. 0d.; but this very high price has been followed by some reaction, the average for 1881 having fallen to £46 9s. 5d. per ton.

Kauri digging is followed under licenses granted by the Crown, the charge being one penny per acre. It affords the chief means of livelihood of the natives in Mongonui, Hokiangi, Bay of Islands, Papakura, Waiuku, and Mangawai, and many of them earn large sums at this occupation. In Hokiangi, Maories have earned six to eight pounds per week, and in Mangawai, the average earnings per digger is from eighty to ninety pounds per year. In 1881, this industry afforded employment to 1160 persons.

Retinite, is a fossil resin, found in the Brown Coals of Drury, and in many of the lignites of Otago. It occurs in small nodules, and short irregular layers, and more rarely, lumps are found as large as a man's head. It is transparent, brittle with conchoidal fracture, of a pale yellow to dark brown colour, melts without decomposition, ignites easily, and burns with a sooty flame and bituminous smell. Its hardness is 2; S.G. 1·034, and it becomes electric by friction. Its composition is Carbon, 76·65, Hydrogen 10·38, Oxygen 12·78, Ash ·19.

SULPHUR

is found in the volcanic region of Auckland, near the boiling springs, in the cracks and fissures of the ground. White Island, in the Bay of Plenty, is the crater of an ancient volcano, and is still an active solfatara. Only at one point, Crater Bay, is the island accessible, and landing, at all times difficult, is impossible in rough weather. At the landing, there

is a flat plain three-quarters of a mile wide, seamed with fissures, emitting sulphurous steam. Beyond this plain lies a hot lake, the water of which contains free hydrochloric and sulphuric acids, and is of a deep green colour, and a little further, enveloped in dense masses of vapour, is the active solfatara. Surrounding the whole like a great amphitheatre, stand the rocky walls of the crater, from every crevice and fissure of which steam is hissing and roaring, while the dark boiling and bubbling sulphurous waters below, add to the horror and grandeur of the scene. Close to the edge of the lake there is a large deposit of yellow sulphur, almost pure, (99·9 per cent.) and in the broken and uneven ground between the lake and the foot of the walls are masses of rock and green sulphur, (yielding 94·1 per cent. sulphur). These deposits, and also some of similar character, which are found on Whale Island, are being utilised for the supply of works at Tauranga; a veritable case of snatching a living from the gate of Hades.

A very curious instance of the occurrence of native sulphur is reported from Wangapeka, Nelson, where it is seen in cavities in quartz reefs, traversing slate rocks which are said to exhibit no evidence of any volcanic action.

BARYTES

for which there is now such an extensive demand, (chiefly for those purposes of adulteration to which it so readily lends itself), has been found at several "claims" at the Thames, also at Whangaroa, north of Bay of Islands; at Red Island, south of Cape Kidnappers; and near Mount Egmont. Crystallised specimens have been brought from near Collingwood. No large vein has yet been discovered, but the frequent occurrence of fragments make it probable that some such exist.

NON METALLIC MINERALS OF MINOR IMPORTANCE.

Alum Shales exist at several points, and those at Waikouaiti, Otago, have been utilised for the manufacture of Alum. The analysis of the decomposed shale is—

Sulphate of Alumina	11·80
„ Iron	5·27
„ Lime	1·31
„ Soda and Potash	14·60
Insoluble in water	33·30
Water and Loss	33·72

Gypsum occurs crystallised in the clays at Moeraki, Otago. Also in considerable quantity, in lenticular masses in the upper tertiaries, of marine origin, at Waikouaiti, where it is manufactured into plaster of paris.

Phosphate rock has been obtained at Coral Queen Island, Auckland, yielding 74·2 per cent. Phosphate of Lime, and 7·2 organic matter.

Lithographic Stone has been found at Amuri Bluff of fairly good quality, and also in the formations of similar age and character, at Abbey Rocks, Westland.

Dolomite has been found in a bed of considerable thickness at Collingwood ; and crystals of

Magnesite from the same locality, yielded 94·82 per cent. Carbonate of Magnesia.

Kieselguhr or *Diatomaceous Earth*, the substance used in the preparation of dynamite, occurs in deposits of considerable thickness near Foxton, Wellington, and at Napier, and Marlborough.

Steatite is fonnd in a massive dyke, 30 feet wide, at Parapara valley, near Collingwood. The dyke has been traced in a N.E. direction for a considerable distance, the country along the west side being a crystalline limestone. The mineral is compact with a slight schistose structure, or fibrous and could be easily obtained in masses of large size.

Talc of a delicate green colour occurs in Westland ; and

Asbestos at Milford Sound.

Pumice is found at Napier in considerable quantities, but not usually of a quality sufficiently fine to be useful in the arts.

Jade occurs in veins, in the serpentine and hornblendic schists of the West Coast, and was formerly in great request *by the Maories*, the native name being "poenamu." It is

extremely hard and tough, and before the introduction of iron was used for weapons.

Common Serpentine occurs in extensive masses in Nelson and Otago; while the variety known as *Noble Serpentine*, is found at Milford Sound of a delicate sea green color, translucent and capable of a high polish.

Among non-metallic minerals, none is of more essential importance than salt, but the author believes that no indications of a deposit of rock salt have yet been reported.

PRECIOUS STONES.

Of the stones classed as "precious," and used for purposes of personal adornment,

Rubies have been found at Manawatu, and Waipori;

Topaz large and fine at Waipori;

Sapphire, one specimen, a deep blue but much fissured water worn pebble in the gold digging near Collingwood;

Zircon at Timbrill's Gully;

Garnets at Waipori, Kakanui, Rakaia River, Kumara, and Auckland;

Carnelian at Moeraki, Otepopo;

Agates, Otago Harbour, and Auckland;

Jasper and *Chalcedony* at Moeraki, Otepopo, Auckland;

Labradorite at Flagstaff Hill;

Chrysolite, at Saddle Hill.

Some excitement has recently been caused by the announcement that *Diamonds* had been discovered at Raglan, about 70 miles from Auckland. A party who went out prospecting returned with a number of crystals, and four of these on being tested, were pronounced to be diamonds, though too small to be of value as precious stones. Possibly the rigorous search of the locality which is sure to ensue, may lead to some more valuable results.

BUILDING STONES

in great variety, and of excellent quality, are widely dispersed throughout the Colony.

True crystalline *Granites,* flesh colored and grey, are

found at Stewart's Island, and on the West Coast, at Dusky Bay, Preservation Inlet, and Chalky Inlet where they are quarried; and *Gneissic Granites* occur in many other of the West Coast Sounds. Green *Syenites* are quarried at Blind Bay for use in Nelson.

Basalts and *Volcanic Rocks*, locally termed blue stones, are extensively used. In the North Island, these include some recent lavas and scorias. The Mount Eden *Scoria* used in Auckland City, is of a very dark grey color, hard and durable, but, being porous, has the defect of absorbing damp. Those used in the South Island are older, and are all of submarine origin. They are largely quarried at Bank's Peninsula, and in the hills about Dunedin. A trachytic *Porphyry* with sanidine is worked at Portobello, and a quartzose *Trachyte* at Port Lyttleton. At Port Chalmers a *Volcanic breccia*, consisting of a tough greenish paste, in which are embedded fragments of granite, syenite &c., is quarried, and is one of the best building stones in use, being easy to work and durable. A quartzose porphyry is obtained from the Malvern Hills.

Freestones are of very general occurrence, associated with the coal beds at the base of the tertiary and upper part of the secondary formations wherever these are found. The tertiary formations commonly comprise beds of argillaceous and calcareous sandstones. The celebrated Oamaru "White Freestone" is more properly a granular limestone, containing as it does 90 per cent lime; it is of a light cheerful color, so soft when first quarried as to be easily sawn, is unrivalled for carving purposes, hardens by exposure, and is scarcely affected by atmospheric influences. It is largely exported and has been used in some of the public buildings at Melbourne.

Limestones.—The rocks of the older formations, the equivalents of our Silurian, Devonian, and Carboniferous systems exhibit a remarkable want of those enormous masses of calcareous strata which form so characteristic a feature of these formations in this country.

Crystalline Statuary Marbles are associated with the an-

attention to the mineral wealth possessd in no stinted measure by this highly favoured land. True it is that he has had to note many cases of failure, and it is a pity that almost all those mining adventures in which English capital has been employed, have resulted in disappointment. Yet it would be irrational and unjust to conclude that this must necessarily be so, for in almost every case it is easy to see that failure has arisen either from illconsidered selection of locality, or from "management" one scarcely knows how rightly to characterise. In some cases, too, deposits have been found and attacked in the most superficial manner, and on failing to give immediate returns they have been condemned and precipitately abandoned; while in others much capital and illspent labour have been thrown away on deposits of such a character, or in situations so inaccessible, as to forbid even a promise of success. Anyone who has read the foregoing pages ought to have no difficulty in believing that the rocks of the colony are the repositories of immense mineral riches. Riches which await only the vivifying touch of wisely directed capital and labour to become available for the use and enjoyment of this and future generations of the people of New Zealand.

EDWARD MILES, PRINTER, CLIFTON CRESCENT, BIRKENHEAD.

LIVERPOOL GEOLOGICAL ASSOCIATION.

Field Meeting, May 14th, 1883.

Held at Monsal Dale and Bakewell. Conducted by Dr. C. Ricketts, F.G.S. The following places were visited: The "Spar Mine" at Monsal Dale; Section of Toadstone at Cresbrook Mills; Sections of Upper Cherty Limestone and Toadstone; deposits of Tufa; Black Marble Quarries at Ashford; Chert Quarries at Bakewell.

Field Meeting June 2nd. 1883.

Held at Leasowe. Conducted by Mr. T. Mellard Reade, C.E. F.G.S. The Post-Glacial deposits at Dove Point were examined (Vide Report.)

Ordinary Meeting, June 4th, 1883.

Held at the Free Library, the President, Mr. Henry Bramall, M. Inst. C.E., in the Chair.

Mr. F. J. Lawrenson, was elected a Member.

Mr. W. R. Cooper, B.A., 11, Northumberland Terrace, Everton, was proposed as a Member.

DONATIONS.

"The Story of the Earth and Man" and "Fossil Men" by Dr. Dawson —*presented by Mr. J. D. Howard*; "The Cromer Forest Bed," by T. Mellard Reade, C.E., F.G.S. *presented by the Author*; "Proceedings of the Liverpool Literary and Philosophical Society" 1881-82, *from the Society.*

The following Communication was read:—

REPORT OF THE EXCURSION TO LEASOWE, (*June 2nd, 1883,*)

By W. H. Miles.

The party proceeded from Meols Station to Dove Point on the shore, under the guidance of Mr. T. Mellard Reade,

C.E., F.G.S.—who stated that the beds to be seen at this point were similar to, but in some respects better developed than those to be observed on the opposite shore near the River Alt, in Lancashire.

Attention was first called to the æolian sand forming the newest shore deposit. At the base of this formation were stratified beds ; the lowest, a soil bed resting on the Peat, was originally a land surface on which existed a Roman station. It is from this bed that most of the antiquities described in Hume's "Ancient Meols" have probably come. The coins range from Roman through Saxon and Mediæval to Modern times ; whilst other objects found, chiefly ornaments or objects of personal use, are of equal if not of greater age. Above these stratified beds,—some of which may be tidal silt, while others are due to sand blown into slacks in which fresh water has accumulated from time to time,—is the blown sand of the dunes, which, cut into cliffs by the sea, and denuded by the wind, exhibits a rocky structure suggestive of some of the Triassic sandstones of the neighbourhood.

The group of beds already noticed rest immediately upon peat, the "Superior Peat and Forest-Bed." This deposit contains numerous stools or lower parts of the trunks of trees—Oak, Fir, and Birch,—mostly in the natural position they occupied when living, though one or two were to be seen lying prostrate. The tap roots or rootlets of these trees were noticed striking through into the silt below, and it was particularly noted that where two or three trees could be found close together, their roots were interlaced with each other, and could be traced ramifying in all directions.

Below this Peat Bed, a blue laminated clay or silt, of a stiff tenacious character, occurs. This Mr. Reade classes with "The Formby and Leasowe Marine Beds." It is an estuarine deposit containing numerous shells of *Scrobicularia piperata*, and also, in its lower portion, some sand and shore remains—it varies in depth according to locality.

Underneath the Blue Clay is found in some places an inferior Peat Bed, resting directly on the Boulder clay. A

portion of this deposit,—here thinned out very much,—was observed about two inches deep, and contained some rootlets striking through into the clay beneath, but to which plant they belonged was not determined.

It may not be out of place here to mention that the name "Dove Point," near where these deposits occur, is supposed to be derived from the Celtic word "*Dhuv*"- black, probably suggested by the dark appearance caused by the peat, and which would imply that the present condition of the shore has existed much the same since Celtic or early British times.

Mr. Reade explained that succeeding the Glacial Period in which the Boulder Clay was laid down under water, a period of elevation took place, the Boulder Clay became land, and was worn by subaerial denudation into an irregular surface. This is shewn by the fact of the Forest-Beds being found at various depths, ranging from 4 or 6 feet in some places to 60 feet in others; which would not be the case had they accumulated on an undenuded surface.

On this land surface, now elevated, vegetation flourished, giving rise to the lower or Inferior Peat Bed, and then another period of subsidence taking place, the land to a depth of 25 feet above the present mean sea level was submerged, and it was during this period of depression that the Blue Silt of the Formby and Leasowe Marine Beds was laid down by the sea.

Another period of elevation then succeeded,—in which the land stood relatively to the sea much higher than at present, Great Britain and Ireland probably forming part of the Continent of Europe,—and during which the Upper Forest-Bed already noticed was formed.

A partial submergence of the land, with its accompanying marine denudation since this last period, has resulted in the present configuration of the British isles, and locally has caused the formation of the blown sand and tidal silt deposits first noticed.

A careful examination of the trunks and rootlets exposed on the Leasowe shore, afforded conclusive proof that the re-

mains now to be seen occupy the same site in which they grew, and that the theory that they were floated as snags into their present position has no evidence whatever to support it. An objection urged, that in some cases parts of the rootlets are broken off short (which, it was said, ought not to be the case if they are *in situ*), was shewn by Mr. Reade to be explained by the fact, that the wood being now very rotten is broken off along with the peat surrounding it by the action of the sea, but that where the peat is undenuded the rootlets can be traced in it entire.

Mr. Reade also pointed out that the evidence of the Forest Beds at Leasowe has a bearing on a controversy that has been going on regarding a much older deposit, that of the Cromer Forest-Bed underlying the Boulder Clay, and in which trees have been discovered *in situ*. Some geologists assert that these were drifted down as snags, and deposited in their present position by a river which they identify with the Rhine; yet if the evidence in our local case points to the undoubted existence of a Forest-Bed *in situ*, in main particulars agreeing with the published descriptions of the Cromer Forest-Bed, it is only reasonable to suppose that the conditions in both cases have been similar, and that the manner of their formation was identical.

Evening Field Meeting, June 29th, 1883.

Held at Tranmere. Conducted by Mr. William H. Miles. Sections of Drift Deposits in the Excavations for the Mersey Railway, at the foot of Holt Hill, were inspected, by permission of Mr. James Prentice, Manager. In the Borough Road, another cutting was visited, showing angular and sub-angular blocks of sandstone, intermixed with sand lying above the Pebble Beds.

LIVERPOOL GEOLOGICAL ASSOCIATION.

Ordinary Meeting, July 2nd, 1883.

Held at the Free Library, the Vice-President Mr. Charles E. Miles, in the Chair.

Mr. W. R. Cooper, B.A. was elected a Member.

Proposed as Members :—

Messrs. T. M. Johnson, 60, Lord Street; John Nicholls, 11, Chatham Place, Edge Hill; Thomas Maguire, 108, Landseer Road, Everton; and the Rev. Wm. Paton, Mossgiel House, New Ferry, Cheshire.

DONATIONS.

"The Scientific Roll," Edited by Alexander Ramsay, F.G.S.—*presented by the Editor*; "Drift Beds of the North-West of England and North Wales," by T. Mellard Reade, F.G.S.,—*presented by the Author*; "Report and Proceedings of the Belfast Naturalists' Field Club, 1881-82;" "Report" 1882, of the Liverpool Science Students' Association; "Proceedings," No. 6, of the Liverpool Astronomical Society,—*presented by the respective Societies.*

The following Paper was read :—

"ON THE PREPARATION OF ROCKS FOR MICROSCOPICAL EXAMINATION,"

(Principally with Reference to the Sedimentary Rocks.)

By Henry C. Beasley.

I propose in the present paper to give an account of the methods I have myself found most convenient for preparing specimens of rocks for examination under the microscope, with such appliances as may be readily obtained at a small cost; and I shall presume, at the outset, that the object is the examination of specimens collected in the field by the practical geologist, and not the manufacture of microscope slides on an extensive scale.

I will, in the first instance, take for example a piece of ordinary carboniferous limestone, as being a rock of average hardness and compactness, and afterwards shew the somewhat different treatment required by the softer rocks on the one hand, and the harder rocks on the other.

1. The first operation is to procure a thin flake of the rock, say about an inch across: this can often be done by a smart blow of a hammer near the edge, but it can generally be insured by holding the hand specimen of the rock in one hand on a cold chisel fixed to a block of wood, or on the sharp end of a geological hammer, and striking it a sharp blow with a hammer with the other hand.

2. The next operation is to grind one side quite flat. The quickest way of doing this is by rubbing it on a flat piece of hard sandstone, about 14 ins. by 10 ins. sprinkled with coarse emery powder, and kept well wet. A flat piece of iron, or a piece of plate glass is very handy, in case you are travelling about, instead of the flat sandstone, but it does not grind so rapidly, as of course the grinding is in that case done by the emery alone.

3. Having got a flat surface right across the flake, the next process is to remove the roughness. For this I generally use an emery hone of medium fineness, but a piece of plate glass with fine emery is very good. Great care must be taken that none of the grains of coarser emery used in the previous process adhere either to the specimen or to the plate glass, otherwise deep scratches will result, which will require a great deal of labour to get rid of; the specimen must therefore be carefully washed between each operation. I prefer the emery hone to the plate of glass, as there are fewer loose particles of emery about.

4. As soon as you have rubbed it as smooth as possible on the emery hone, wash it carefully, and then rub it with a somewhat circular motion on a water of Ayr stone, and if you are careful not to have any bits of grit or emery about, you will in a minute or so have a surface free from scratches. Instead of the water of Ayr stone, another plate of glass may be used

with very fine emery powder. The glass has the advantage of preserving an even surface, whereas the emery stone and the water of Ayr stone will wear into hollows, however careful you may be to distribute the friction over the whole surface; but they can be readily ground smooth on the sandstone slab used for the first process, and will at the same time tend to produce an even surface on that, and I think that the little trouble is quite compensated by the absence of annoyance from the dirt and grit that always is liable to get about, when emery powder is used. Having freed the surface from scratches, it will be advisable to examine the specimen under the microscope as an opaque object. By wetting the surface and throwing a strong light upon it through a bulls' eye condenser, you will readily make out a good deal of its structure, and that of the minute fossils it contains. Some rocks lend themselves much more readily than others to this mode of examination. If this seems likely to be the case in this instance, it will be well to proceed to polish the specimen. In most cases a thin film of moisture will render the features very distinct, and for rocks that will not readily take a polish, a good way to examine them is to cover the smooth surface with a thin coat of Canada balsam, and cover it with a thin piece of glass. Of course, however, the result is not nearly so satisfactory as when a fine polish has been given to the surface; and this may generally be done by getting as fine a surface as possible on a german hone, or some similar stone, and then polishing it upon a piece of coarse felt well sprinkled with the very finest "putty powder" (muriate of tin) obtainable. It should be kept just damp during the operation. Do not let the felt get at all saturated with water.

5. We will now return to the piece reserved for a transparent section, and which has been rubbed down to a tolerably smooth surface. We next procure a piece of plate glass 1½in. or 2in. square, and on to this we fasten the smooth side of our specimen. The best substance for this purpose is Canada balsam; it can be procured at any chemists, and is generally sold in too soft a condition for use for this purpose, so it will

be necessary to heat it in an open vessel (I generally use a porcelain dish) for some hours, taking care that it does not boil, or the bubbles formed will be a great trouble in succeeding operations. The balsam should be tried from time to time by taking out a small portion on a steel rod, knitting needle, or knife, and cooling it, and when it is hard enough to resist the pressure of the thumb nail, it should be at once removed, as if it is further heated it will become too brittle to use.

Heat the specimen and the piece of glass until as hot as you can bear to touch with the finger, then place a portion of the hardened balsam on the piece of glass, where it will melt, and press the flat surface of the specimen firmly upon it, moving it a little to get the melted balsam evenly spread beneath it to expel any bubbles that may have formed.

When the balsam has thoroughly set, you can grind the stone away with your coarsest emery till it is about $\frac{1}{16}$ in. thick, the square of glass serving as a convenient handle; then it will be advisable to use the finer emery or hones as directed before. It is important now to get as perfectly level a surface as possible, so care must be taken to hold the specimen firmly in one position while using the finer hones. By the time all the scratches are removed the stone will be about $\frac{1}{20}$ in. thick, and it will be advisable to put a fine polish upon it, unless there are any interstices in it, which would hold the putty powder, in which case it is better to finish it on a plain piece of leather. The specimen by this time will probably be somewhat less in diameter than it was, but if not more than an inch in one direction it will make a very good slide, and of course the larger the better, if well done; but practically you will find that it is better to divide it into smaller pieces, therefore just mark it across with a knife, scratching it as deeply as you can, and dividing it into portions about $\frac{1}{2}$ in. square.

You now take the square of glass and scrape off all the balsam you can that may surround the specimen, and then warm it, and when it is thoroughly warm a gentle but firm *lateral* pressure with a blunt instrument, say the handle of

your forceps, will cause the thin section to slide off the glass. Drop it into a watch glass filled with benzine, and when it has soaked a little time, wash it thoroughly with a camel hair brush, and get rid of all the balsam that may adhere to it. Break it across where you scored it with the knife. Each piece is now smooth on one side, and more or less polished on the other; the polished side being finished must be attached to a little disc of thin glass termed a cover glass. These can be had of all sizes, and it is well to have an assortment, so as to be able to suit your specimens. A very convenient size is about ⅝in. diam. and that will suit the present purpose.

(6) Your cover glasses being quite clean, warm both them and your specimens, and place on each cover glass a piece of balsam, and when melted lay a specimen, the polished side downwards upon it, pressing it firmly and moving it a little to expel any bubbles. A small brass or copper stand with a spirit lamp below it will be found most convenient for warming the glasses and specimen in this and subsequent operations; one can be obtained, made specially for this purpose at the microscope dealers, or can be quite easily made by oneself. If the rock be at all friable it is well to let it have enough balsam to thoroughly embed it.

Be careful that there are no bubbles or air spaces between it and the glass, and hold it firmly in a pair of forceps for a few seconds, till it is cool. Then take a narrow slip of glass, 3 in. + 1 in., such as are generally used for microscope slides, and attach your cover glass close to one end of it, with a bit of balsam. Press it down with a spring clip, and leave it for a few hours for the balsam to harden thoroughly, and treat the other pieces in the same way.

The glass slip serves for a handle, holding this grind the specimen on a water of Ayr stone till it begins to be somewhat transparent, and then finish it either on a very fine hone, or on a piece of plate glass with Rottenstone. This is perhaps the best, as it is important to grind it evenly, and the plate glass ensures an even grinding surface. The grinding must be done very carefully, and every minute or

so it should be dipped in water, just washed with a brush, and examined with a lens, or else before you know where you are, it will be quite ground away, or have so broken up as to be useless. As soon as one piece has been made tolerably transparent, put it aside and proceed with the next and as you are now sure of one, you may try to make this next one thinner than the first; if you succeed in doing so, you can return to the first, and grind it to the same or a greater transparency. You next warm the glass slips, and very carefully slide off the cover glasses, with the objects attached to them, and wash them in benzine with a camel hair brush.

(7.) The preparation of the object is now complete, and you proceed to mount it on a glass slip, so that it may be more readily handled and examined, without fear of injury. The best medium for this is Canada balsam dissolved in benzine, so as to be rather thinner than syrup. You take a 3 + 1 in. glass slip, and, having warmed it on the brass stand, drop a drop of the thin balsam in the centre, and then place the cover glass, with the object downwards, of course, upon it, letting one edge down first, and then closing it down like the lid of a box. Press it firmly down, and keep it so, either with a spring clip or lead weight; and leave it a short time, on the warm stand, but be very careful not to let it get hot enough to form bubbles (the thinner the balsam the less liability to bubbles). Then remove any superfluous balsam, and put the slide aside for some days, where it will be free from dust. When it seems quite firmly set, wash off any balsam that may be sticking to the glass with a camel hair brush and benzine, and wash off the benzine with another camel hair brush and some soap and water. When dry it is quite ready for the cabinet, but it will be better able to resist any comparatively rough usage or accident, if you put a ring of white cement round the edge of the cover glass. This is easily done with the aid of a brass turn table sold for the purpose.

I think that by following these directions, and with a

little practice and delicacy of handling, some very fair slides may be turned out. You may, often, however, omit some portions of the process, and still make a very satisfactory examination of a rock. If you can manage to strike off a very thin flake about ½ inch across in the first instance, you can readily smooth down one side, attach it to the centre of a slip, and grind it down there till transparent, and it is at once ready for examination. A corundum file will be found very useful in rapidly rubbing down small specimens; plenty of water must be used with it to keep it cool, as also in all the grinding operations described above.

For grinding down the harder rocks, it will be advisable to use corundum in place of emery, except in the first operation. It can be had in three degrees of coarseness; but the two most useful for our purpose are "medium" and "flour." It can be got at the dealers in dentists' sundries.

In the case of a very friable rock it is advisable to soak it thoroughly in a solution of shel lac or spirits of wine, and let it dry and harden before rubbing it down; but in many cases such a rock can be readily examined after crumbling it by rubbing it in water with a brush, or crushing it gently with the fingers. The powder should then be dried, a small quantity laid on a slide; drop a little benzine upon it, and then a drop of the thin balsam, and cover with a cover glass. For the examination of sandstones a freshly broken surface with a strong light thrown upon it will reveal most of its structure. But it can be reduced to sand as described above, and mounted dry, (do not attempt to examine it without mounting, or the grains of sand will probably do some injury to the microscope). A flat india rubber ring fastened to a slip makes a useful cell; lay the sand in this and cover with a thin cover glass; a little balsam round the edge will hold it securely. For grinding soft rocks, such as coal, a flat piece of pumice stone may be used with advantage. I have purposely said nothing about the use of the lapidary's wheel in this paper, as my object has been to shew how rocks can be prepared for examination by the aid of the most simple and readily obtained apparatus, by any practical geologist.

Field Meeting, July 7th, 1883.

Held at Frodsham, Conducted by MR. CHARLES E. MILES. Good sections of the Waterstones and Lower Keuper Sandstone were seen. An "open fissure," showing waterworn surface, was also noticed. In a quarry in the Building stones near Five-lane-ends, some examples of "sun-cracks" were found. Mr. T. MELLARD READE, F.G.S. directed attention to the occurrence of drift with boulders at a high level. At Dunsdale Hollow, the junction of the Keuper and Bunter rocks was observed.

Evening Field Meeting, July 13th, 1883.

Held at the Dingle, Toxteth. Conducted by MR. G. H. MORTON, F.G.S. The fault in the Upper Bunter was inspected, and good examples of "current-bedding" were seen. Mr. MORTON gave a very instructive address on the Triassic formations occurring in the district, in the course of which he stated that several modifications of the original sub-divisions of the Trias, as laid down by Mr. E. Hull, F.G.S. of the Geol. Survey, and himself, were now found to be necessary, and pointed out that it was probable that all the rocks formerly classed as Lower Bunter either formed part of the overlying Pebble Beds, or else belonged to the Permian formation.

Evening Field Meeting, July 27th, 1883.

Held at Eastham. The junction between the Pebble Beds and (?) Lower Bunter was pointed out by Mr. G. H. MORTON, F.G.S., who gave some interesting remarks on the rocks underlying the Pebble Beds in Lancashire and Cheshire.

EXCURSION TO SHROPSHIRE.

August 3rd to August 6th, 1883.

The route included the country between Wenlock Edge and the Longmynd. DR. C. RICKETTS, F.G.S. conducted the party, which left Liverpool on Friday, August 3rd, and proceeded to Much Wenlock, where the Wenlock limestone quarries, rich in Corals and other remains of animal life in the Silurian period, were visited. At Rushbury, the remains of an interesting Roman Camp were inspected, and, at a little distance further on, the upper Llandovery Beds, with limestone containing the fossil *Pentamerus* were seen in the banks of a small stream. A section of metamorphic rock on Cardington Hill was examined. At Soudley, near the picturesque village of Hope Bowdler, the quarries in the Caradoc sandstone yielded quantities of Cambrian fossils. Church Stretton was reached on Saturday night, and on Monday the ascent of the Longmynd was made, along the romantic gorge of the Carding Mill, by the Lightspout Waterfall. The Port Way (an ancient British track) having been reached, another valley was descended, leading to Little Stretton, where a fine section is exposed, showing the junction of the Llandovery conglomerates with the Longmynd rocks. After dinner at Church Stretton, in the evening, on the motion of the President, Mr. HENRY BRAMALL, M. Inst. C.E., a vote of thanks was passed to Dr. RICKETTS for his kindness in conducting the Excursion, and rendering so much valuable assistance.

LIVERPOOL GEOLOGICAL ASSOCIATION.

Field Meeting, August 25th, 1883.

Held at Grimshaw. Conducted by MR. HENRY BRAMALL, M. Inst., C.E., President. A section of Gannister beds was inspected from above the railway cutting at Pimbo Lane Station. The natnre of these beds, consisting of flagstones interspersed with shales, and containing but two workable seams of Coal, was explained. Gannister (which gives its name to the series) is the clay containing a large proportion of silica, which forms the base of the Coal seams. Fine sections in the Millstone Grit were seen at Houghton's Quarry and Grimshaw Delf. Specimens containing sulphate of baryta were found at the former quarry. The characteristic grit of the sandstone, caused by the decomposition of its felspar, was noticed in weathered specimens. In the banks of the Grimshaw brook, several exposures of Lower Bunter Sandstone were observed.

Ordinary Meeting, September 3rd, 1883.

Held at the Free Library, Mr. HENRY BRAMALL,, M. Inst., C.E., President, in the chair.

The following were elected as members :—

Messrs. J. Nicholls, T. Maguire, T. M. Johnson, and the Rev. W. Paton.

Proposed as members :

Messrs. Edmund Rowe, 23, Frodsham Street, Tranmere; Charles Potter, 101, Miles Street; George Downie, 19, Oakfield Road; and Raoul James, 309, Upper Parliament Street, Liverpool.

AUDITORS.

On the motion of Mr. Brennan, seconded by Mr. Rowland, it was resolved that Messrs. T. R. CONNELL and HOPKIN THOMAS be appointed Auditors for the Session.

DONATIONS.

"Transactions" Vol. II; "Report", 1882, of the Liverpool Engineering Society;—"Proceedings" 1882-83, Liverpool Naturalists' Field Club; Ditto, Vol. I, Liverpool Astronomical Society;—Ditto, Vol. 8, No. I, and "Report 1882, of the London Geologists' Association; — "Report" 1882-83, Chester Society of Natural Science,—*presented by the respective Societies*; — "The Mineral Resources of New Zealand," by Henry Bramall, M. Inst, C.E.,—*presented by the Author*;—Ninth Annual Report on the Colonial Museum, Wellington, N. Z. by Dr. Hector;—*presented by Mr. Bramall.*

A Paper was read on—

MANGANESE ORES.

By Herbert Fox.

The following few notes, though possessing no claim to originality, may, perhaps, be of some interest, by directing attention to a group of minerals, some of which are of undoubted economic importance, while others afford examples of some of the large number of chemical compounds existing in nature.

Compounds of Manganese are very widely distributed, though the element itself is never found free in a natural state. Black oxide of manganese, a substance long used to decolourize glass, and called *magnesia nigra*, from its resemblance to the load-stone, was formerly included among the ores of iron. Towards the end of the eighteenth century, it was proved that the metal contained in this mineral is distinct from iron, and possesses characters peculiar to itself; and, in the year 1774, Gahn extracted from it the metal manganese. This may be obtained by reducing the dioxide with charcoal or soot at a high temperature. A carbide of the metal is then formed corresponding to cast iron, which may be refined by heating it with manganese carbonate. As thus obtained the metal has a greyish white colour, and a fine grained structure; it is very brittle, and rapidly oxidises on exposure to the air. Its specific gravity is about 8. It is almost infusible, and readily attacked by mineral acids with evolution of hydrogen.

The form in which manganese is used in the arts is that of a naturally occurring oxide, or that of some compound manufactured from one of these, and, as its applications are very numerous, large quantities of these ores are consumed.

The imports into Great Britain for the years 1879-1881, were as follows :—

1879............	12,172 tons,	value £45,870.
1880........ ...	16,085 ,,	,, £67,070.
1881............	18,743 ,,	,, £71,149.

of which the following quantities were imported into Liverpool:—

1879...........	5,110 tons, value	£19,346.
1880...........	8,159 ,, ,,	£31,515.
1881...........	7,699 ,, ,,	£30,727.

London, Glasgow, and some of the towns on the east coast—Newcastle, Hartlepool, and Middlesborough, also receive large quantities of manganese.

These ores come principally from the Black Sea, Spain, New Zealand, California, and South America. England itself, in 1881, produced upwards of 2,300 tons; Wales upwards of 300, and Ireland about 250 tons; a total of about 2,900 tons, represented in value by over £6,000. These figures show a large increase as compared with the previous two years, the manganese mined in Great Britain and Ireland, in 1879, being only about 820 tons, valued at about £1,500. The total quantity of manganese ores consumed annually in Great Britain, at present, may be estimated at from 20,000 to 25,000 tons.

These ores consist mainly of pyrolusite, psilomelane, and wad, and are largely used in the manufacture of chlorine, of iron and steel, of glass and pottery, by electrical instrument makers in the manufacture of Leclanche batteries, by oil boilers and varnish makers, and also for bleaching tallow and fat. Considerable quantities are consumed in the manufacture of the sulphate and borate of manganese, which are used as "driers" in boiling oil, the borate, however, being made principally, if not entirely, on the continent.

Although the naturally occurring oxides, pyrolusite, psilomelane, wad, &c., are the chief ores of manganese possessing economic value, perhaps it will not be altogether unprofitable to glance briefly at the properties and occurrence not only of these, but also of some of the rarer of manganese minerals, more particularly with reference to those features by which they may be most readily identified.

As regards the general properties of manganese minerals before the blowpipe, or when treated with chemical reagents,

the manganese can be readily detected in substances containing, besides manganese, no other metallic oxides which give coloured beads with borax or microcosmic salt, by simply dissolving them in those fluxes on the platinum wire in the oxidising flame, and then treating the bead with the reducing flame. The hot beads appear amethyst red, but on cooling, are red inclining to violet, and lose their colour when treated for some time in the reducing flame. Microcosmic salt is not so intensely coloured as borax, and loses its colour in the reducing flame much sooner. When a small proportion of other colouring oxides is present they alter the amethyst colour obtained in the oxidising flame slightly, or not at all, but occasionally show their own colour when the manganese colouration has disappeared under the reducing flame.

A method by means of which manganese can be detected in minerals when present only in exceedingly small quantities, is to fuse the substance with two parts of soda and one part of nitre on platinum foil, in the oxidising flame. The oxide of manganese dissolves in the soda to a transparent green mass, consisting of manganate of soda, which flows round the undissolved portion, and is coloured distinctly bluish green when cold.

Minerals containing any oxide of manganese higher than the protoxide evolve chlorine when heated with hydrochloric acid.

If the substance contains or consists of a metallic sulphide or arsenide, it must be heated on charcoal before the above tests for manganese can be applied.

Among the various minerals, differing considerably in chemical composition, of which manganese is an essential constituent, we find the following :—

Pyrolusite.—This is one of the most important ores of manganese. It crystallises in forms belonging to the orthorhombic system, but is frequently found without any distinct crystalline form. H. 2—2·5· G. 4·82. Lustre, metallic. Colour, iron black, dark steel-grey or sometimes bluish. Streak, black, or bluish black. Opaque and rather brittle. Compo-

sition, when pure, $Mn\ O_2 = Mn\ 63 \cdot 2\ \%$; $O\ 36 \cdot 8\ \%$. It may be distinguished from *psilomelane* by its inferior hardness and by its generally being crystalline. It is found in many places on the Continent, and in America.

Hausmannite. — Tetragonal. Cleavage, basal, nearly perfect. Also granular-massive. Particles strongly coherent. H. 5·55. G. 4·7. Lustre, submetallic. Colour, brownish black. Streak, chesnut brown. Opaque. Fracture uneven. Composition, $Mn_3\ O_4$. Occurs with porphyry, along with other manganese ores, in fine crystals, near Ilmenau, in Thuringia, Ilefield in the Harz, also reported from Alsace.

Braunite.—Tetragonal, also massive. H 6—6·5. G. 4·75—4·82. Lustre, submetallic. Streak and colour, dark brownish black. Fracture, uneven. Brittle. Composition, $Mn_2\ O_3$. *Marceline*, an impure variety, contains silica. Occurs both crystallized and massive in veins traversing porphyry at Oehrenstock, near Ilmenau, and at Elgersberg.

Manganite.—Orthorhombic, crystals longitudinally striated and often grouped into bundles, also columnar, seldom granular, stalactitic. H·4. G. 4·2—4·4. Lustre, submetallic. Colour, dark steel grey—iron black. Streak, reddish brown, sometimes nearly black. Opaque; minute splinters, sometimes brown by transmitted light. Fracture, uneven. Composition, $Mn_2\ O_3 + H_2\ O$, containing, when pure, $Mn_2\ O_3 = 89 \cdot 8\%$ $H_2\ O = 10 \cdot 2.\ \%$. Occurs in veins traversing porphyry, associated with calcite and barite at Ilefield, in the Harz, Ilmenau and Oehrenstock in Thuringia, in Sweden and Norway, in Nova Scotia, New Brunswick, and other places in North America. In our own country it is found in Cornwall, Cumberland, Devonshire, and Somersetshire; in Aberdeenshire, Scotland, and in several places in Ireland.

Varvacite.—H. 2·5—3. G. 4·283—4·623 may be considered as an altered manganite, consisting largely of pyrolusite.

Psilomelane is found in massive or botryoidal masses. Colour, black or greenish black. Streak, reddish or brownish black. Shining. H. 5—6. G. 4—4·4. Composition, essen-

tially hydrated peroxide of manganese. It also contains some baryta or potash, and is a compound somewhat varying in its constitution. It is an abundant ore, and is associated usually with pyrolusite. Oxide of cobalt has been detected mixed with the ore. It occurs in the same localities as pyrolusite, and the two are often in alternating layers.

Wad is the name given to certain ores of manganese occurring in amorphous and reniform masses, and sometimes incrusting or as stains. They are mixtures of different oxides, and cannot be considered as chemical compounds or distinct mineral species. The principal varieties are *Bog Manganese*, *Asbolite* (a wad containing CoO) and *Lampadite* or *Cupreous Manganese*, (a wad containing 4 °/₀ to 18 °/₀ CuO, and often CoO.) They are most probably the results of the decomposition of other ores, partly of oxides, and partly of manganese carbonates.

The above enumerated minerals are naturally occurring oxides. When heated in a closed tube they yield more or less water, and some give off oxygen. Heated with HCl they evolve Cl. The small amount of baryta contained in braunite, hausmannite, and psilomelane, can often be detected by the feeble, yet distinct baryta flame produced by a small splinter, especially after moistening with H Cl.

Rhodocrosite or *Diallogite* is a native carbonate of manganese, part of the manganese being generally replaced by lime and often by magnesia or iron. It occurs in rhombohedral crystals, also more commonly in globular and botryoidal masses of radiated structure. H. 3·5—3·5. G. 3·4—3·7. Lustre vitreous or pearly, usually pink or rose coloured. Streak, white. Translucent to opaque. Before the blowpipe it decrepitates violently. Dissolves in fluxes with effervescence, and reacts like oxide of manganese containing iron. It occurs commonly in veins with ores of silver, lead, and copper, and with other ores of manganese. It is found in Hungary, Transylvania, the Harz, Saxony. It is abundant in the silver mines of Austin, Nevada, and at Placentia Bay, Newfoundland.

The following phosphates of manganese are found occurring naturally.—

Triplite. Orthorhombic, imperfectly crystalline. H·5—5·5. G. 3·44—3·88. Lustre, resinous, inclining to adamantine. Colour, brown to black. Streak, yellowish grey or brown. Subtranslucent to opaque. Composition, a phosphate of manganese and iron containing lime, magnesia and fluorine. Found at Limoges, in France, with apatite, and in Silesia. *Zwieselite,* a brown variety, has been found near Zwiesel, in Bavaria, in quartz.

Triphylite or *Triphylin.* Orthorhombic and massive. H. 5. G. 3·54—3·6. Colour, greenish grey, also bluish, often brownish black externally. Translucent in thin fragments. Composition, a phosphate of iron and manganese, containing lithia and occasionally lime, potash and soda. It occurs in Bavaria, Finland, and at Norwich, Massachusetts.

Heterosite and *Hureaulite* may be considered as varieties of triphylin.

The phosphates of manganese yield more or less water when heated in a closed tube, and before the blowpipe fuse very easily to a globule and colour the flame. Those free from lithia, give a bluish green phosphoric acid flame, the others produce a lithia colouration at the same time. With fluxes they react for manganese and iron.

A silicate of manganese is found occurring naturally as *Rhodonite,* which occasionally crystallises in forms belonging to the triclinic system, but which usually is massive. H 5. 5—6.5. G. 3.4—3.68. Lustre, vitreous, pearly or dull. Usually pink or rose coloured, occasionally reddish brown. Transparent to opaque.

Bustamite is a variety containing 9 °/₀ to 15 °/₀ lime, which replaces part of the manganese. It often contains carbonate of lime. Colour, greyish red.

Fowlerite, contains zinc and occurs in crystals and foliated.

Rhodonite is fusible in the reducing flame to a reddish glass, in the oxidizing flame to a black metallic globule, and

is unacted upon by acids. It is found in Sweden, the Harz, the Ural and in Cornwall.

There are two native sulphides of manganese; the first, a monosulphide known as *Alabandite*, *Manganblende*, or *Manganglanz* contains Mn=63·3 % S=36·7 % Colour, blk. Streak green. It is found in Transylvania. The second, *Hauerite* is a disulphide. Mn=46·3 % S=53·7 %. Colour, reddish brown. It has been found at Kalinka in Hungary.

Manganese is found associated with the metal tungsten in the minerals.

Wolframite, a tungstate of iron and manganese.

Huebnerite, a tungstate of manganese.

Megabasite, a tungstate of manganese containing a little iron.

Among other manganese minerals are *Crednerite*, an oxide of copper and manganese; *Franklinite*, an oxide of iron, zinc and manganese; *Chondrarsenite*, occurring at Paisberg, in Sweden, as yellow grains in barite, probably an arseniate of manganese. *Sussexite*, found on Mine Hill, Sussex County, New Jersey, associated with franklinite, zincite and other manganese and zinc minerals, is a borate of manganese and magnesia. *Manganese alum* or *Apjohnite* has been found on the shores of the Great Salt Lake, and a manganese and magnesium alum in the Canton Uri, Switzerland.

Such is a brief review of the principal ores of manganese, and though few possess economic value, yet a certain amount of interest must attach itself, even in practical minds, to the less useful members of a family which possess relations of such commercial importance as pyrolusite, psilomelane, manganite and wad.

Field Meeting, September 8th, 1883.

Held at Speke. Conducted by Mr. T. S. KEYTE. The section of Pebble Beds extending to north of the station was examined. Afterwards, the party inspected a cutting in the Boulder Clay to the south of the railway bridge, in which some good examples of boulders containing hornblende crystals and a few shells were found.

Visit to the Museum, September 22nd, 1883.

Conducted by Mr. F. P. MARRAT, who exhibited and described the "Philip's Collection" of Minerals, opened to the members by permission of Mr. T. J. MOORE, the Curator. Mr. MARRAT explained the unique character of the Collection, which comprises the actual specimens from which Philips wrote his celebrated works on Mineralogy.

END OF VOLUME III.